Abstract Booklet

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Rationale

The TESS/*Kepler* Asteroseismic Science Consortia (respectively TASC and KASC) consist in international scientific collaborations formed around the asteroseismic activities of NASA's TESS and *Kepler* space missions. An annual series of conferences, the most important in the field of asteroseismology, has been held since their inception. This culminated in the organization, in 2024, of the 8th TESS/15th *Kepler* Asteroseismic Science Consortium Workshop (TASC8/KASC15) in Porto, Portugal.

The past decade has witnessed significant advancements in the development and application of precise asteroseismic probes of stellar astrophysics, covering different aspects of the physics in various types of stars. Asteroseismology has emerged as a powerful tool, successfully integrating with other techniques to study stars, planetary systems, and stellar populations. The ongoing refinement of the theoretical framework, through improved models, and the employment of precise data analysis methods continue to broaden the influence of asteroseismology on stellar astrophysics in general.

TASC8/KASC15 welcomed the international astronomical community to Porto and aimed to serve as a platform for a comprehensive review and discussion of the latest findings in the field of asteroseismology. The focus was placed on new ways of improving the physics in stellar models, addressing aspects such as convection, angular momentum transport, magnetic fields, and mixing. Additionally, the workshop delved into approaches for leveraging the wealth of existing and upcoming data. Recognizing the synergies with other topics, ranging from Galactic astronomy to exoplanets, the program also featured sessions dedicated to these interdisciplinary connections.

Scientific Organizing Committee

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Invited and Contributed Talks[1]

[1] Abstract, author, and affiliation information is displayed as provided by the authors (i.e., unedited).

Session 1: The transformative decade ahead

[Invited] IT1.1

Title: PLATO Core Stellar Science

Author: Kévin Belkacem
Affiliation: LESIA - Paris Observatory

Abstract: The primary target (or Core Program) of the PLATO mission consists of a large sample of about 250,000 main-sequence and subgiant stars, mainly with spectral classes F, G and K. Through the high-precision, long-term photometric monitoring of these stars, combined - for the brightest among them - with their thorough asteroseismic analysis, PLATO will ultimately enable us to determine their radius, mass and age with an unprecedented precision and accuracy. This presentation will give an overview of the Core Program from the stellar science perspective, the output that the stellar physics community can expect from it, and the science that we will be able to conduct therewith. While the main output will be the radius, mass and age determination of all stars in the Core Program sample, seismic parameters, rotation periods and activity-related properties will also be delivered to the community for each star where they can be estimated.

[Invited] IT1.2

Title: PLATO's Complementary Science Program

Author: Conny Aerts
Affiliation: KU Leuven

Co-authors: Andrew Tkachenko (1); PLATO Complementary Science Collaboration
Co-authors affiliation: (1) KU Leuven

Abstract: ESA's PLATO space project stands for PLAnetary Transits and Oscillations of stars. The nominal mission has a 4-year duration, with an extension option up to 8 years of operations. PLATO's launch is scheduled for December 2026 and after its cruise to L2 and the commissioning, its 26 telescopes will stare for a minimum of 2 years at its identified first southern field-of-view (aka LOPS2). The Core Science program of the mission concerns the detection and characterisation of an unprecedented sample of exoplanets, with emphasis on planets in the habitable zone of sun-like host stars. Aside from its Core Program, PLATO has an extensive Complementary Science program (PLATO-CS) for 8% of the total data rate. PLATO-CS has the aim to maximise the scientific return of the mission. This will be achieved via a Guest Observer (GO) program open to the worldwide community. In this invited talk, we present an overview and the current status of the PLATO-CS activities. Their aim is to optimally prepare the stellar, galactic, and extragalactic science communities to submit competitive GO proposals by investigating and showcasing the capabilities of the mission. We provide several examples of scientific topics fitting in PLATO-CS's realm, backed by preparatory work based on existing photometric surveys and/or PLATO simulations.

[Contributed] CT1.1

Title: MOCKA – A PLATO mock asteroseismic catalogue of intermediate to massive stars

Author: Nicholas Jannsen
Affiliation: KU Leuven

Co-authors: Nicholas Jannsen (1), Andrew Tkachenko (1), Pierre Royer (1), Joris De Ridder (1), Dries Seynaeve (1), Suzanne Aigrain (2), Murat Uzundag (1), and Conny Aerts (1,3, 4)
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Abstract: With ESA's PLATO space mission set for launch in December 2026, a new photometric legacy and a future of new scientific discoveries awaits. By exploring scientific topics distinct from the Core Science program, the scientific component coined the PLATO Complementary Science program (PLATO-CS) provides a unique opportunity to maximise the scientific yield of the mission. PLATO-CS will be available to researchers world-wide through a Guest Observer (GO) program. In this oral contribution, we highlight PLATO's potential in the topic of Pulsating Stars across the Hertzsprung-Russell diagram outside the Core program. Specifically, a PLATO mock asteroseismic catalogue (MOCKA) of intermediate to massive stars will be presented as a first benchmark to quantitatively highlight the potential of PLATO-CS. MOCKA is based on a magnitude limited (G<17) Gaia catalogue and is a product of realistic end-to-end PlatoSim simulations of stars from the first (of minimal 2-year duration; Southern hemisphere) pointing field of PLATO. We will provide a detailed discussion of the oscillation mode detectability for gravity mode pulsators, whose pulsations primarily trace the radiative region near the convective core boundary, thus making them unique stellar laboratories to study internal structure and evolution. Prior to mission launch, activities like MOCKA help us understand the limits of the mission as well as highlight the opportunities to push astrophysics beyond current stellar models.

[Contributed] CT1.2

Title: The Polarimetric Revolution in Asteroseismology

Author: Derek Buzasi
Affiliation: Florida Gulf Coast University

Co-authors: Daniel Cotton (1); Jean Perkins (1); Jeremy Bailey (2); Richard Townsend (3)
Co-authors affiliation: (1) Monterey Institute for Research in Astronomy; (2) University of New South Wales; (3) University of Wisconsin

Abstract: We are in the midst of an observational asteroseismology revolution, initiated by early space missions such as WIRE and COROT and brought to its current advanced state through the dramatically expanded capabilities and data sets of Kepler and TESS. These have given us a tool to peer inside stars across most of the HR diagram; supplementing space-based photometry with ground-based tools such as spectroscopy has deepened the reach of that tool. Polarimetry can further expand the reach of asteroseismology. Stars pulsating in non-radial modes are expected to have periodic variability in polarization, but generally only at the ppm level, and until recently polarimetric instruments had precision limits of not much better than 100 ppm. However, in the last two decades instruments such as POLISH and HIPPI have successfully achieved ppm-level precision, and the newest instruments such as HIPPI-2 and PICSARR do so efficiently and routinely. We are now on the verge of a polarimetric revolution in asteroseismology, which is of particular importance as an additional constraint for massive stars where interpretation of asteroseismic data can be particularly complex. I will show how we have used polarimetry in combination with TESS data to perform mode identification in Beta Cru, to explore the origins of variability in the bright supergiant star Deneb, and I will discuss our near future plans for application of this new tool to a wider range of stars.

[Invited] IT1.3

Title: Asteroseismology with the Roman Space Telescope

Author: Marc Pinsonneault
Affiliation: Ohio State University, Dept. of Astronomy

Abstract: Time domain studies have revolutionized stellar astrophysics. In particular, asteroseismology of cool evolved giants has enabled both exquisite studies of stellar physics and unprecedented information about stellar populations. In this talk I make the case for Roman, currently schedule to be launched in May 2027, as an exciting opportunity for asteroseismology. A keystone Roman program, the Galactic Bulge Time Domain Survey (GBTDS), will monitor the central parts of the Galaxy for 450 days over 5 years for planet microlensing. The cadence and precision are a natural match to seismology, and the combination of large cameras, small pixels, and IR imaging will enable up to half a million detections of the poorly understood Galactic Bulge. I outline the key challenges in realizing this potential, and how Roman will complement TESS and PLATO for asteroseismology in the next decade.

Session 2: TESS/TASC

[Invited] IT2.1

Title: TESS Mission: Status and Ongoing Mission Planning

Author: George R. Ricker
Affiliation: MIT

Co-authors: TESS Science Team

Abstract: The Transiting Exoplanet Survey Satellite (TESS) is NASA's ongoing mission for discovering exoplanets and exploring the time-variable sky. The TESS observatory is in excellent health, and its scientific output has continued to grow rapidly over the past 6 years, resulting in >7000 planet candidates and ~2000 scientific publications— including 576 papers in 2023 alone. A sizable fraction of these publications address targets and topics related to asteroseismology. TESS's 2nd Extended Mission (EM2:2023-2025) will bring its sky coverage to >95%. In addition, more than 80% of the sky will have been observed at least twice at the completion of EM2, giving access to longer-period planets and host stars. In EM2, the time sampling of TESS full-frame images (FFIs) was improved to 200 sec, enabling a broader range of time domain astrophysics and multi-messenger astrophysics (TDAMMA) studies, as well as allowing variability in ~100 million stars to be searched with no preselection required. Rapid 20s cadence observations of a sample of pre-selected stars—either GI/DDT targets or TOIs— is also continuing. EM2 has also adopted the TESS Image CAlibrator (TICA) data product, making fully-calibrated 200s full-frame images publicly available within ~2-3 days of downlink. For TESS's 3rd Extended Mission (EM3:2025-2028), we will build on accomplishments of the past six years by potentially conducting long duration surveys of the TESS-JWST-Roman continuous viewing zones near the ecliptic poles, thus enabling the discovery of more long period systems and also coordinating with (or complementing) the PLATO baseline survey.

[Invited] IT2.2

Title: TESS Asteroseismic Science Consortium (TASC)

Author: Jørgen Christensen-Dalsgaard
Affiliation: Stellar Astrophysics Centre, and Department of Physics and Astronomy, Aarhus University

Abstract: TASC, and before that the Kepler Asteroseismic Science Consortium (KASC), have played important roles in the organization of asteroseismic observations with the Kepler and TESS missions and the collaboration on the analysis of the data. This has been supported by the Kepler and TESS Science Operations Centres (KASOC and TASOC). In my talk I shall provide a brief overview of the development of these consortia and discuss the organization of TASC. In addition I shall present a few scientific highlights, resulting from the development of the TESS mission, and discuss future possibilities but also challenges faced by TASC and TASOC after the end of the funding of the Stellar Astrophysics Centre.

Session 3: Convection, rotation, magnetic fields, and transport of chemical elements

[Invited] IT3.1

Title: Ensemble Stellar Rotation

Author: Jennifer van Saders
Affiliation: University of Hawaii

Abstract: Stellar rotation is both ubiquitous and a thorny problem for stellar models and stellar characterization. Space-based photometric missions like TESS have enabled two fundamental leaps forward in our observational studies of stellar rotation: the ability to study truly large samples (tens of thousands) of rotation rates from surface spot modulation, and the ability to construct ensembles of stars where interior rotation rates are known thanks to asteroseismology. I will discuss what these population-level studies of rotation have taught us about the evolution of rotation with time, its interconnectivity with stellar activity, and internal angular momentum transport. I will also review the current prospects for using rotation as a tool to measure stellar ages via techniques such as gyrochronology.

[Contributed] CT3.1

Title: Asteroseismic Diagnostics of Core-Envelope Rotational Misalignment

Author: Joel Ong
Affiliation: Institute for Astronomy, University of Hawai‘i

Abstract: Existing techniques for asteroseismic rotational measurements assume a priori that a single rotational axis suffices to describe all parts of a star. However, the action of tidal torques from misaligned companions, or the deposition of angular momentum owing to their engulfment, will bring the rotational axis of a convective envelope out of alignment with the radiative core, breaking azimuthal symmetry. I examine the widths, and apparent distribution of power between components, of the rotationally split multiplets that would emerge under these circumstances; I pay particular attention to the phenomenology of p/g mixed modes as seen in evolved sub- and red giants. In the aligned case, the relative amplitudes of multiplet components is determined by the inclination of the rotational axis; radial differential misalignment causes this instead to vary from multiplet to multiplet, depending on the sensitivity kernels associated with these multiplets. Other geometrical degeneracies prevent internal misalignment from being uniquely constrained from seismic multiplet splittings alone. These degeneracies may be broken using either supplemental spectroscopic measurements, or by exploiting the near-resonance avoided crossings of mixed-mode oscillators. I apply the new observational methodology that results from this discussion to revisit Kepler-56: a red giant with misaligned planetary system whose existing seismic rotational characterisation already suggests such internal misalignment.

[Contributed] CT3.2

Title: The effects of rotation-induced mixing in secondary clump red giant stars

Author: Lorenzo Martinelli
Affiliation: School of Information and Physical Sciences, The University of Newcastle, Australia

Co-authors: Lorenzo Martinelli (1), Andrea Miglio (2), Patrick Eggenberger (3), Gaël Buldgen (3,4), Hannah Schunker (1)
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Abstract: Rotational mixing (RM) is a key process in stellar evolution, capable of extending the stars' lifetime and altering their evolution. This is particularly important in the case of mixing at the edge of convective cores. The stellar mass threshold for which helium is ignited in non-degenerate conditions is sensitive to the efficiency of internal mixing processes that can replenish the core with extra fuel during hydrogen burning, thus producing a more massive helium core. Secondary clump red giant stars are just massive enough to ignite helium in non-degenerate cores, making them ideal candidates to constrain the efficiency of RM. We evolved a grid of stellar models from pre MS to thermally pulsing asymptotic giant branch, for a range of masses 1.7-3.0 $M_\odot$ and nine initial rotation rates. We calibrated the RM during the main-sequence (MS) from models with an advective-diffusive transport of angular momentum. We then generated single-age synthetic stellar populations (SPs) around 1 Gyr of age assuming distributions of initial rotation at the zero age MS. We found that primary and secondary clump stars coexist in the same single-age SP, producing a double red clump feature in the Hertzsprung-Russell diagram, only if there is a broad distribution of initial rotation rates. Finally, we compared our synthetic SP with a sample of Galactic field stars, indicating that RM may be an important candidate in reproducing the distribution of classic observables and asteroseismic masses.

[Contributed] CT3.3

Title: Accurate asteroseismic envelope rotation rates for evolved red giants

Author: Felix Ahlborn
Affiliation: Heidelberg Institute for Theoretical studies

Co-authors: E. Bellinger (1) S. Hekker (2) S. Basu (1) D. Mokrytska
Co-authors affiliation: (1) Yale University, Department of Astronomy (2) Heidelberg Institute for Theoretical Studies

Abstract: All stars rotate, and the rotation rate becomes more internally concentrated as a star evolves. However, there is evidence that current models of the evolution of stellar rotation are not able to reproduce the observed internal rotation rates of red-giant stars. Here, we focus on examining how best to determine the internal rotation profile in red giants in order to provide good constraints on the angular momentum transport mechanisms at play. We have developed a new asteroseismic inversion method to measure accurate core and envelope rotation rates. We show that reproducing the mixed-mode character of the observed oscillation modes is crucial to estimate accurate rotation rates using the rotational inversion method. Finally, we construct an ensemble of stellar reference models reproducing the mixed-mode character of the observation to obtain a statistically robust estimate of the internal rotation rates and the systematic errors. This will be an important probe to follow the evolution of angular momentum along the red-giant branch.

[Contributed] CT3.4

Title: Variability of mercury-manganese stars through the eyes of TESS

Author: Oleg Kochukhov
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Abstract: Mercury-manganese (HgMn) stars exhibit distinctive chemical peculiarities marked by an overabundance of Xe, P, Mn, and various heavy elements. Unlike their magnetic counterparts found in similar regions of the H-R diagram, HgMn stars lack strong surface magnetic fields. Nonetheless, a subset of these stars displays subtle rotational modulation in spectral line profiles, suggestive of evolving surface spots. This inhomogeneous surface structure yields a faint photometric rotational modulation. The advent of the TESS satellite, conducting high-precision photometric surveys across nearly the entire sky, presents unparalleled opportunities to explore the variability of HgMn stars. Such investigations can constrain the prevalence of surface spot formation and probe variability arising from other phenomena such as pulsations and binarity. In this presentation, I provide an overview of recent studies conducted on HgMn stars utilizing TESS data. Our comprehensive variability survey revealed that up to 84 percent of HgMn stars exhibit evidence of surface spots and doubled the known population of HgMn stars in eclipsing binaries. Moreover, intriguing instances of ellipsoidal and heartbeat variability have emerged, alongside several cases featuring multi-periodic SPB and tidally-induced pulsations in HgMn stars. Lastly, ongoing research delves into the investigation of long-term spot variability on HgMn stars, leveraging TESS light curves spanning multiple cycles.

Session 4: Solar-like oscillators

[Invited] IT4.1

Title: Asteroseismology of solar-type pulsators

Author: Charlotte Gehan
Affiliation: Max Planck Institute for Solar System Research

Abstract: The advent of ultra-high photometry space missions has revolutionized our understanding of the physical processes governing stellar evolution by enabling to directly probe stellar interiors through asteroseismology. CoRoT and Kepler have provided outstanding results for thousands of pulsating stars, and the harvest continues with the ongoing TESS mission and the future PLATO mission expected to be launched by late 2026. This talk will review the state of the art concerning asteroseismology of solar-type pulsators, including evolved oscillating stars that offer the opportunity to study the physical conditions in the stellar core through the mixed modes in their oscillation spectrum. I will present recent observational results and their impact on stellar physics, exoplanet science, and Galactic archaeology, including an outlook on future perspectives.

[Contributed] CT4.1

Title: Imprint of magnetic activity cycle on solar asteroseismic characterisation

Author: Jérôme Bétrisey
Affiliation: University of Geneva

Co-authors: Jérôme Bétrisey (1); Martin Farnir (2)
Co-authors affiliation: (1) Geneva University; (2) Liège University

Abstract: Building on the success of previous missions, asteroseismic modelling will play a key role in future photometry missions, such as PLATO and CubeSpec. Despite these remarkable achievements, asteroseismology has revealed significant discrepancies in the physics of theoretical stellar models, which have the potential to bias stellar characterisation at the precision level demanded by PLATO. The current modelling strategies largely overlook magnetic activity, assuming that its effects are masked by filtering the so-called “surface effects”. Given the presence of activity cycles in multiple solar-like oscillators, and activity variations in about 60% of Kepler observations of main-sequence stars (Santos et al. 2019a,b), we measured the impact of magnetic activity on the asteroseismic characterisation of the Sun based on 26 years of GOLF and BiSON observations (Bétrisey et al., submitted). While magnetic activity is partially absorbed in the treatment of surface effects, we found a discernible imprint of the activity cycle in the determination of the solar age. Notably, this imprint persists across both BiSON and GOLF datasets, with significant variations of up to 6% observed between solar minima and maxima. Considering that the Sun exhibits low levels of activity, our study underscores the looming challenge posed by magnetic activity for future photometry missions, and prompts a potential reevaluation of the asteroseismic characterisation of Kepler’s most active targets.

[Contributed] CT4.2

Title: Influence of rotation and magnetic field on the stochastic excitation of acoustic modes

Author: Leila Bessila
Affiliation: CEA IRFU, Département d'Astrophysique, LDE3

Co-authors: Leïla Bessila (1), Stéphane Mathis (1)
Co-authors affiliation: (1) Département d'Astrophysique, CEA Saclay

Abstract: Amplitudes of acoustic modes in solar-like stars are intrinsically linked to the properties of turbulent convection in their envelope, which acts as their excitation source. Recent observational works using results of the Kepler space mission, showed that acoustic modes' signals are not detected in a large fraction of solar-type stars, where they are nevertheless expected because of their convective envelope. This non-detection is a function of both stellar magnetism and rotation. One hypothesis is that the excitation source term is too low to trigger the oscillations. In addition, observations of solar-type stars show that the amplitudes of these stellar acoustic modes are modulated along their magnetic activity cycles. A key to understanding these observations could be to remember that rotation and magnetic fields strongly influence convection. Their action is most of the time ignored in the models that allow astrophysicists to predict acoustic modes' amplitudes. To assess the impact of rotation and magnetic field, we extend the state-of-the-art of the formalism describing the stochastic excitation of stellar acoustic modes. We show that the turbulent source terms are modified by the presence of rotation and magnetism. We illustrate how the acoustic waves amplitudes are modulated, depending on their rotation period and their magnetic activity. This work helps predict their detectability in rotating magnetic solar-like stars, which is paramount to preparing PLATO.

[Contributed] CT4.3

Title: What curves $\Delta\nu$?

Author: Saskia Hekker
Affiliation: Heidelberg University & HITS

Co-authors: Y. Elsworth(1), S. Basu(2), F. Ahlborn(3), L. Buchele(3,4)
Co-authors affiliation: (1) University of Birmingham (2) Yale University (3) Heidelberg Institute for Theoretical Studies (4) Heidelberg University, Centre for Astronomy

Abstract: Stars are to first order described as spheres of gas. They do however deviate somewhat from homogenous spheres of ideal gas and these deviations are imprinted in their normal oscillation modes. One of these imprinted features is that the large frequency separation, $\Delta\nu$, in solar-like oscillators is not constant: it is curved as a function of frequency. Two questions arise naturally 1) what in the structure of the star is responsible for this second order variation of $\Delta\nu$, and 2) how does the variation depend on global properties of the star like mass and age. We analyse a few thousand red-giant stars to derive empirical relations between α (the curvature coefficient) and $\Delta\nu$. Comparing these empirical relations with those obtained from stellar evolution models shows that a) the α - $\Delta\nu$ relation for red-giant branch stars is mass dependent, and b) that the α - $\Delta\nu$ relations obtained from the models differ from the empirical ones. We also calculate sensitivity kernels for α that allow us to determine the regions responsible for the curvature. This will provide important insights for improving the physics in our models and reconciling the difference between the empirical α - $\Delta\nu$relationships and those based on models.

[Contributed] CT4.4

Title: Interferometric observations of solar-like pulsators: a survey to constrain scaling relations

Author: Mathieu Vrard
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Co-authors: Mathieu Vrard (1) Denis Mourard (1), Orlagh Creevey (1), Sébastien Deheuvels (2)
Co-authors affiliation: (1) Observatoire de la Côte d'Azur (2) Institut de Recherche en Astrophysique et Planétologie

Abstract: The asteroseismic scaling relations allowing to estimate the masses and radii of solar-like pulsators have now been vastly used to investigate a great number of physical problems in the local universe. However, recent results on luminous red giants and binaries show that the scaling relations appear to be inconsistent with dynamical measurements and Gaia data in these specific regimes. It is therefore necessary to obtain precise and accurate independent measurements to evaluate and understand the limits of seismic scaling relations. It is the program that is proposed by the ERC ISSP (Interferometric Survey of Stellar Parameters) which has the objective of obtaining direct interferometric constraints on nearby stars with an angular diameter larger than 0.2 mas. The use of the SPICA instrument in the visible with the 300m bases of the CHARA interferometer indeed allows us to reach a precision of 1% on the radius. Thus, the realization of a survey of hundreds of asteroseismic targets with interferometric observations becomes possible. That is what the ERC ISSP is proposing and has started to perform in 2023. In this talk we will present the first results of this interferometric survey on several solar-like pulsators, finding a coherence between the interferometric and asteroseismic radii. We will also examine the consequences these results have on the use and calibration of seismic scaling relations.

Session 5: Convection, rotation, magnetic fields, and transport of chemical elements

[Invited] IT5.1

Title: Seismic constraints on magnetic fields inside stars

Author: Sébastien Deheuvels
Affiliation: IRAP

Abstract: All observational constraints on the internal rotation of stars consistently point to the existence of a missing ingredient in our modeling of angular momentum transport inside stars. Magnetic fields are one of the most serious candidates to produce this additional transport. The recent seismic detection of magnetic fields in the cores of red giants has opened new avenues to make progress on this important question. The suppression of non-radial modes in a subclass of red giants and in a main-sequence B star has also been interpreted as the potential consequence of strong internal magnetic fields. In this presentation, I will review the seismic methods that have now been explored to reveal magnetic fields in stellar interiors. I will present the constraints that were obtained on the strengths and topologies of these fields, putting the emphasis on the efforts that are still needed to construct an exhaustive catalog of magnetic red giants. Finally, I will briefly touch on how these measurements compare with the few predictions available so far on magnetic angular momentum transport in stars.

[Contributed] CT5.1

Title: A simple expression for the magnetic suppression of mode amplitudes

Author: Jonas Müller
Affiliation: Heidelberg Institute for Theoretical Studies

Co-authors: Quentin Coppée (1); Saskia Hekker (1)
Co-authors affiliation: (1) Heidelberg Institute for Theoretical Studies

Abstract: Internal magnetic fields can suppress the amplitudes of the non-radial modes of red giant stars when their strength approaches the critical field strength, at which the magnetic forces become comparable to the buoyancy. We performed Hamiltonian ray tracing simulations of magneto-gravity waves to investigate the trapping of oscillation modes in the presence of an internal magnetic field. Our results indicate that the onset of the mode suppression can be described by a simple expression. It smoothly connects the regime without suppression with the regime with complete suppression and depends only on the ratio between the strength of the magnetic field and the critical field strength. Using this expression, we can estimate the occurrence of stars with suppressed dipole modes and the morphology of their power spectra as a function of stellar mass, age, and magnetic field strength.

[Contributed] CT5.2

Title: Mapping the surface of pulsating magnetic stars with Zeeman-Doppler Imaging

Author: Chloe Gutteridge
Affiliation: LESIA - Observatoire de Paris

Co-authors: Chloe Gutteridge (1); Coralie Neiner (1); Claude Catala (1)
Co-authors affiliation: (1) LESIA - Observatoire de Paris

Abstract: Zeeman-Doppler Imaging (ZDI) is a technique that inverts a series of spectropolarimetric data allowing the reconstruction of the magnetic geometry and field strength of a star. It has proved to be a powerful tool in understanding the complexity and configuration of stellar magnetic fields. Previously, it has been performed on the assumption that both the surface brightness and line profiles vary only with rotation. These are not valid assumptions for pulsating stars and can lead to errors in the magnetic field strength and geometry. I present the application to modelled pulsating stars of the first code able to correctly map the surface of magnetic pulsators, and contrast it to results that would be achieved by standard ZDI. By modelling the pulsations which could be observed by space photometry missions like TESS, we can include their additional effects in new time-dependent surface brightness maps and synthetic line profiles to fit spectropolarimetric observations. This modification of the open source ZDI code of Folsom et al. (2018) will lead to improved accuracy in stellar and magnetic properties, allowing us to perform a rigorous analysis of magneto-asteroseismic data, an essential step in the magneto-asteroseismic modelling of the internal structure of stars.

[Contributed] CT5.3

Title: The efficiency of mixed modes for angular momentum transport

Author: Beatriz Bordadágua
Affiliation: Heidelberg Institute for Theoretical Studies (HITS)

Co-authors: Felix Ahlborn (1); Saskia Hekker (1)(2)
Co-authors affiliation: (1) Heidelberg Institute for Theoretical Studies, Germany; (2) Heidelberg University, Germany

Abstract: Core rotation rates of red giant stars inferred from asteroseismic observations are substantially lower than predicted by current stellar models. This indicates the lack of a mechanism capable of efficiently transporting angular momentum (AM) in radiative interiors. Mixed pressure-gravity modes are a promising candidate as they have been shown to efficiently extract AM from the core of evolved red giants. We developed a post-processing code to compute AM transport by mixed modes and its interplay with the meridional circulation. This code uses MESA stellar evolution models as input. We find a spin down of evolved red giant's cores as a result of mixed modes and show their effect on the rotation profile as a function of evolution. Finally, we compare the computed core and surface rotation rates with asteroseismic observations.

[Contributed] CT5.4

Title: Mixing in massive main-sequece stars by internal gravity waves

Author: Jack Morton
Affiliation: University of Exeter

Co-authors: Jack Morton (1); Isabelle Baraffe (1,2); Thomas Guillet (1)
Co-authors affiliation: (1) University of Exeter; (2) École Normale Supérieure, Lyon

Abstract: Understanding mixing through the stably stratified regions of stars is critical in placing them correctly on evolutionary tracks and interpreting abnormal abundances observed at their sufaces. Asteroseismic studies depend on 1D evolution models, so correctly determining mixing rates to improve these is essential. Here I will present our study of vertical mixing driven by internal gravity waves based on multi-dimensional hydrodynamical simulations with our fully compressible code MUSIC (Baraffe et al. 2023; Le Saux et al. 2023; Morton et al. 2024, in prep). Among others, two mechanisms of mixing by IGWs in stars are commonly quoted: firstly, thermal diffusion providing a non-restorative effect to the waves, leaving material 'swept away' from its equilibrium (Press 1981; Zahn et al. 1997), and secondly waves sustaining a strong enough shear to create weak localised turbulence (García López & Spruit 1991). We show that for massive main sequence stars, neither of these mechanisms are likely to be significant enough to produce the mixing required to obtain correct evolutionary tracks, and even less so for stars evolved past zero-age main sequence. Furthermore, we warn that tracer particle methods used to measure mixing by IGWs are prone to subtle numerical artefacts due to integration of periodic flows over long time scales. Diffusion coefficients based on such methods are used in stellar evolution codes to interpret observations and should be taken with great caution.

Session 6: Solar-like oscillators

[Contributed] CT6.1

Title: Probing the internal structure of low-mass main-sequence stars using structure inversions

Author: Lynn Buchele
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Co-authors: (1) Earl Bellinger; (2) Sarbani Basu; (3) Saskia Hekker
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Abstract: Observations from Kepler have yielded a set of main-sequence solar-like oscillators with many precisely measured oscillation mode frequencies, which provides an avenue to probe their internal stellar structure. For each of these stars, the frequencies of our best-fit model show small but significant deviations from the observed frequencies. These differences suggest that our models are not fully reproducing the internal structure of the observed star. Using asteroseismic structure inversions, we localized and quantified some of these differences, in particular, the differences in the sound speed profile of the inner 30% of the star by radius. We will present the results of applying structure inversions to around 50 main-sequence stars with masses between 1 and $1.6 M_{\odot}$. The inversions reveal significant sound speed differences in approximately 50% of the stars and, in the most extreme cases, reveal a discrepancy of roughly 15% between model and observation. We will also present several potential changes to the microphysics in an attempt to improve stellar models.

[Contributed] CT6.2

Title: MCMC inversions of the internal rotation of Kepler subgiants

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Co-authors: Loïc Fellay (1), Jérôme Bétrisey (2), Sébastien Deheuvels (3), Martin Farnir (1), Eoin Farrel (2)
Co-authors affiliation: (1) Université de Liège, (2) University of Geneva, (3) IRAP, Université de Toulouse,

Abstract: The measurement of the internal rotation of post-main sequence starsfrom space-based photometry missions, CoRoT, Kepler and TESS has demonstrated the need for an efficient angular momentum transport in stellar interiors (e.g. Beck et al. 2012, Deheuvels et al. 2015, Gehan et al. 2018, amongt other). So far, no clear solution has emerged and the observed trends remain challenging to explain. We apply a new MCMC inversion technique (Fellay et al. 2021) to existing the six Kepler subgiant targets (Deheuvels et al. 2014 Buldgen et al. accepted in A&A) and test various shapes of the internal rotation profile. We show that large-scale fossil magnetic fields (Kissin & Thompson 2015, Takahashi & Langer 2020) are unable to explain their internal rotation, in line with Di Mauro et al. 2018 and Fellay et al. 2021 for red giants. We constrain the location of the transition in the rotation profile for the most evolved stars and find that some exhibit a transition located close to the border of the helium core while one clearly does not. We conclude that various processes might be at play to explain the data, but that revealing the physical nature of the angular momentum process will require a consistent detailed modelling of all subgiants available, particularly the youngest (Deheuvels et al. 2020). Moreover, increasing the number of stars for which such inferences are possible (e.g. with PLATO) is paramount given the key role they play in validating transport process candidates.

[Contributed] CT6.3

Title: Asterosemismic analysis of the ‘Methuselah’ star

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Abstract: The ’Methuselah’ star is one of the benchmark stars for the Gaia mission, thus knowing its properties very well is a high priority, and it has already been the subject of several studies, including a determination of its angular diameter (eg. Karovicova et al. 2020). It is among the oldest known stars in the Galaxy and very metal-poor with a metallicity of [Fe/H]~ −2.4 (Bond et al., 2013), further stressing the importance of studying this star in detail. Fortuitously, it is also one of the brightest metal-poor halo stars (Creevey et al., 2015), opening up the possibility of conducting an asteroseismic analysis. However, this has not yet been achieved. We have obtained one sector of 20-sec TESS data, and herein the oscillations in the ‘Methuselah’ star are apparent. In this contribution, I will present the outcome of our analysis, including a comparison with existing results. I will highlight what asteroseismology can bring to the table and emphasize that good external constraints are of paramount importance. Scrutinising the ‘Methuselah’ star will not only advance our understanding of this particular star, but also of oscillations in very metal-poor stars in general. For example, oscillations have only been detected in very few stars of this low metallicity (eg. HD 122563, Creevey et al., 2019), thus the 'Methuselah' star may represent the highest-numax metal-poor star where a detailed asteroseismic modelling, including mixed modes, is possible to date.

[Contributed] CT6.4

Title: Decoupling Mixed Modes: Stretched Frequency Recovers Pure P-mode Frequencies In Red Giants

Author: Yaguang Li
Affiliation: University of Hawaii

Co-authors: Joel Ong (1); Daniel Huber (1)
Co-authors affiliation: (1) University of Hawai`i

Abstract: Non-radial oscillations in red giants exhibit mixed characters due to the coupling of p and g modes. This results in uneven spacings in both periods and frequencies for these mixed modes, complicating the analysis of p or g mode cavities. An existing technique --- the stretched period --- aims to transform mixed-mode frequencies to the underlying true g-mode frequencies. This enables direct analysis of g-mode period spacings, buoyancy glitches, as well as rotational and magnetic splittings. In this work, we introduce a complementary approach --- the stretched frequency --- that reconstructs the true p-mode frequencies from mixed modes. We demonstrate its important applications, including (1) the identification of acoustic glitches using non-radial modes, (2) the determination of envelope rotation rates, and (3) the accurate correction of surface effects for mixed modes, without order shifting as encountered in standard methods that rely solely on mode inertia. We applied this method to measure acoustic glitch parameters for $\sim$300 RGB stars, effectively doubling the number of constraints obtained from p modes compared to previous studies. The newly introduced stretched frequency method, along with the stretched period, forms a new array of methods that fully decouples the information from mixed modes for the first time, offering clear insights into red giants oscillation properties and providing better tools for stellar modelling.

[Contributed] CT6.5

Title: Signature of the spin-down stalling in the stellar magnetic activity

Author: Ângela Santos
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Co-authors: Diego Godoy-Rivera (2); Savita Mathur (2); Margarida S. Cunha (1); Rafael A. García (3)
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Abstract: Once main-sequence (MS) solar-like stars transitioned from the saturated to the unsaturated regime in magnetic activity, their evolution was perceived as monotonic, with rotation rate and activity gradually decaying. However, Kepler revolutionized this perspective, showing that the unsaturated regime splits into different regimes. One transition, causing a stalling in the MS spin-down, is attributed to core-envelope coupling and the consequent angular-momentum transfer between a fast core and a slow envelope. In this work, we find evidence of this transition in the magnetic activity of the full Kepler MS sample and NGC 6811. We investigate the magnetic-activity evolution in the Kepler MS sample, by computing activity sequences according to the relative rotation. We find the sequences clustering at two distinct regions: 1) at high activity levels coinciding with stars near the transition above, where a behavior inversion is observed; and 2) at low activity levels corresponding to slow rotators close to the detection limit potentially facing a weakening of the magnetic braking. Focusing on NGC 6811, we find evidence for enhanced magnetic activity, that remains for significant timescales, in stars that have already transitioned. These results support the recent proposition that the strong shear encountered during the core-envelope coupling phase can cause enhanced activity. This study will help shed light on the interplay between rotation, magnetic activity, and their evolution.

[Contributed] CT6.6

Title: Asteroseismic measurement of core and envelope rotation rates for 2006 red giant branch stars

Author: GANG LI
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Co-authors: Sebastien Deheuvels (1), Jerome Ballot (1)
Co-authors affiliation: IRAP, Toulouse, France

Abstract: Mixed modes of RGB stars enable us to study the internal physics from core to surface, such as differential rotation. However, envelope rotation rates have been measured for only a dozen RGB stars so far. The limited sample hinders the theoretical interpretation of angular momentum (AM) transport in post-main-sequence phases. We apply a new approach to calculate the asymptotic frequencies of mixed modes, which accounts for the near-degeneracy effects and leads to more proper measurements of envelope rotation rates. By fitting these asymptotic expressions to the observations, we obtain measurements of the properties of g modes in about 2500 stars. Among these, we measured the core and envelope rotation rates in 2006 stars, doubling the size of pre-existing catalogues. We find a bi-modal distribution of the core rotation rates, implying that some stars could experience a different AM transport. We also increase the sample of stars with measured envelope rotation rates by two orders of magnitude, and find a decreasing trend between envelope rotation rates and evolution, implying that the envelopes slow down with expansion, as expected. We find that the core-to-envelope rotation ratios are around 20 and show a large spread with evolution. Several stars show core-to-surface ratios between 1 and 2, suggesting peculiar AM transport in their progenitors. We also discovered more stars below the degeneracy sequence, providing the opportunity to study stellar mergers.

Session 7: Clusters

[Invited] IT7.1

Title: Asteroseismology of Stellar Clusters

Author: Enrico Corsaro
Affiliation: INAF - Osservatorio Astrofisico di Catania

Abstract: Open clusters are in general young to medium-aged objects that populate our Galaxy, containing up to a few thousands stars and being characterized by the presence of a single stellar population sharing common properties of chemical composition and age. Globular clusters are instead much older objects, with up to millions of stars, that typically contain more than one single stellar population in their interior. In both scenarios, stellar clusters represent unique laboratories for testing stellar evolution theory in detail and with high accuracy through the combination of different and complementary diagnostics. In this talk I will showcase how asteroseismology applied to stars in clusters represents a powerful approach for improving our understanding of stellar physics. In particular, I will present the main efforts that were conducted on oscillating cluster stars through the observations acquired by the space missions NASA Kepler, K2, and TESS. In the last part of my talk, I will provide an outlook on the future of this science, hence briefly discuss what we may expect from upcoming space missions such as NASA Roman Space Telescope and ESA PLATO, which will give scientists the opportunity to continue the legacy already started by Kepler about 15 years ago.

[Contributed] CT7.1

Title: Asteroseismic masses of red giant and RR Lyrae stars in K2 globular clusters

Author: Csilla Kalup
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Abstract: In recent years, asteroseismology of Kepler K2 globular clusters M4 and M80 has revealed us new aspects of their pulsating and oscillating stars: new detections of modulation and low-amplitude extra modes in RR Lyrae stars, integrated mass loss estimates for evolved stars, or the presence of potential sub-populations of the red giant branch. Here we present a detailed seismic analysis of red giant branch (RGB), horizontal branch (HB) and asymptotic giant branch (AGB) stars in the metal-poor cluster, NGC 5897, which is only the third K2 cluster to be analyzed. We obtained our mass estimates both from scaling relations and from RR Lyrae seismology. We also processed five RRc stars in M4 and detected new millimagnitude additional modes that can be used for seismic modeling. For the first time, we have a direct comparison of RR Lyrae and red HB star masses inferred from largely independent seismic analyses, and find perfect agreement at 0.66 solar masses. This allows us to use RR Lyrae seismic masses in fainter clusters, such as NGC5897 and M80 where oscillations in red HB stars are no longer detectable. By sampling the RGB, HB and AGB stages, we can compare the average stellar masses in the three clusters for these phases and estimate mass loss between the stages. As M4, M80 and NGC5897 have significantly different metallicities ([Fe/H]=-1.1, -1.8 and -2.0, respectively), they are excellent candidates for testing whether metal-poor stars lose less mass than the enriched ones.

[Contributed] CT7.2

Title: Improving gyrochronology: a new benchmark data set and enhanced age inference model

Author: Phil Van-Lane
Affiliation: University of Toronto

Abstract: In 2023, we presented a proof-of-concept Bayesian inference framework based on a novel Normalizing Flow machine learning model to infer gyrochronological ages for open cluster stars. Here, we present the expansion of this model to include a training data set of ~10,000 stars from 30 open clusters with measured rotation periods, which we compiled from 12 literature sources. We have also standardized our catalogue to Gaia DR3 photometry, which we de-reddened using 3D dustmaps. Our updated model now includes per-star cluster membership probabilities that are standardized across clusters, and propagation of observational and cluster age uncertainties through the inference framework. We will present the results of stellar and cluster age recovery tests and stellar age estimations from the application of our framework to field stars as a comparison to literature. Finally, we estimate the expected precision from this model and discuss the implications of any systematics in this new benchmark data set.

[Contributed] CT7.3

Title: The Cep--Her Association: analysis of a homogeneous sample of 196 young dSct stars with TESS

Author: Simon James Murphy
Affiliation: University of Southern Queensland

Co-authors: Tim Bedding (1), Anuj Gautam (2), Ronan Kerr (3)
Co-authors affiliation: (1) University of Sydney, (2) University of Southern Queensland, (3) University of Texas at Austin

Abstract: The recently-discovered Cep--Her Association has subgroups with ages of ~20-50 Myr. With TESS, we find it contains 196 delta Scuti stars, making it by far the largest sample of delta Scuti stars of similar age and metallicity. This opens up analyses that are not possible with smaller or more heterogeneous populations. Here, we present three of them: 1. a nu_max--Teff relation has been sought for delta Scuti stars for some time, with mixed success, which perhaps stems from the inclusion of stars with disparate properties, such as metallicity and age. We analyse the nu_max--Teff relation of this homogeneous sample, the results of which will be presented here for the first time. 2. Using échelle diagrams, we measure the asteroseismic large spacing, Dnu, for 70 stars, and find a correlation between Dnu, rotation, and age that allows rapid rotators seen at low inclinations to be distinguished from slow rotators. 3. We measure the pulsator fraction of the delta Scuti instability strip in this young sample and find it to peak at 94±4% -- higher than in the Pleiades and much higher than the Kepler dataset. We thereby identify a trend of increasing pulsator fraction in younger populations. Aside from the population-level studies, we show that asteroseismology is capable of determining stellar ages at a precision that is useful for distinguishing the ages of different subgroups in the association.

[Contributed] CT7.4

Title: Exploring binarity and pulsations in massive stars: towards a comprehensive understanding

Author: Federica Nardini
Affiliation: Newcastle University

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Abstract: Correctly modelling the internal structure and evolution of massive stars is crucial. The combination of asteroseismology and binarity remains underutilised but holds immense potential. Deriving spectroscopic masses from radial velocities, core masses and interior rotation profiles from asteroseismology, and including constraints on the age and metallicity of a star from cluster membership allows a unique opportunity to calibrate stellar evolution theory. In this talk, I will outline the initial results of my PhD project, which involves spectroscopic investigation and asteroseismic modelling of B-type stars within four young open galactic clusters of varying ages (13-30 Myr). I will discuss the binary fraction of each cluster, shedding light on the prevalence of binary systems and their orbital parameter distributions. Furthermore, I will address the characterisation and identification of B-type pulsators within the same four galactic clusters. This marks the first attempt at binary-asteroseismic modelling of these systems, providing new perspectives on young massive binary systems. By characterising binary systems spectroscopically and conducting asteroseismic modelling, we aim to gain deeper insight of fundamental properties of massive stars and refine our understanding of stellar evolution, including physical mechanisms that determine core masses. The ultimate goal is to delve into the interplay between binary interactions and pulsations to better comprehend massive stars.

Session 8: Convection, rotation, magnetic fields, and transport of chemical elements

[Invited] IT8.1

Title: Novel Seismic Probes

Author: Masao Takata
Affiliation: University of Tokyo

Abstract: Recent space missions such as CoRoT, Kepler and TESS provided high-quality data of stellar oscillations, which clearly possess high potential of investigating the global and internal structure of the stars. In fact, these data enabled us not only to perform well-established analyses in much higher precision than before, but also to find new phenomena, which could lead to a new insight into the structure. Since different types of stars have different properties of oscillations, it is necessary to examine what kinds of analyses are most appropriate for each type of stars based on proper theoretical understanding of their oscillations as well as the quality of available data. In this presentation, I will focus on recent development of some of these analyses and discuss their future prospects.

[Contributed] CT8.1

Title: Toward an accurate modelling of convective boundaries in F-type stars

Author: Morgan Deal
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Abstract: The transport of chemical elements in main sequence stars is still far from being understood and is responsible for large uncertainties in stellar models. The study of the signatures of seismic acoustic glitches in solar-like oscillations has proven successful in revealing internal stellar features such as the helium second ionisation zone and the location of the base of the surface convective zone. The latter is particularly important for chemical transport, as it strongly affects the efficiency of atomic diffusion, especially in F-type stars. Furthermore, the complex signature of the glitch in the r010 ratios currently prevents any measurement of the extent of the convective core, which is particularly important for constraining the core overshoot and determining the accurate age of these stars. In this talk, we present an analytical development that links the physical conditions in the penetrative convective (PC) region to the signature in the r010 frequency ratios. We apply this model to Kepler Legacy F-type stars and show that if the envelope PC is responsible for the signature in the observed r010 ratios, then the PC extends much deeper than in the Sun for the hotter stars. We present different ways of interpreting these results by revisiting the standard approach to measuring glitch signatures. This opens up new possibilities to constrain the transport of chemicals in these stars and to improve their current modelling in stellar evolution models.

[Contributed] CT8.2

Title: Failure of Mixing-Length Theory to Explain Supergranular-Scale Convection

Author: Chris Hanson[2]
Affiliation: New York University Abu Dhabi

Co-authors: Srijan Das (2); Prasad Mani (3); Shravan Hanasoge (3,1); Katepalli Sreenivasan (4,1)
Co-authors affiliation: New York University Abu Dhabi (1); Princeton University (2); Tata Institute for Fundamental Research (3); New York University (4)

Abstract: The Sun is an excellent laboratory for understanding convection in main sequence stars. Supergranules, which are solar flow features with a lateral scale of 30-40,000 km and a lifetime of ~24 hours, form a prominent component of the Sun's convective spectrum. However, their internal flows, which can only be probed by helioseismology, are not well understood. Here, we analyze Dopplergrams recorded by the Solar Dynamics Observatory satellite to identify and characterise ~23,000 supergranules. We find that the vertical flows peak at a depth of ~10,000 km, and remain invariant over the full range of lateral supergranular scales, contrary to numerical predictions. We also infer that, within the local seismic resolution (>5000 km), downflows are ~40\% weaker than upflows, indicating an apparent mass-flux imbalance. This may imply that the descending flows also comprise plumes, which maintain mass balance, but are simply too small to be detected by seismic waves. These results challenge the widely used mixing-length description of stellar convection.

[2] Replaced by Prasad Mani as the speaker.

[Contributed] CT8.3

Title: 3D Time-dependent convection model for asteroseismology

Author: Stephane Lizin
Affiliation: Université de Liège

Co-authors: DUPRET Marc-Antoine
Co-authors affiliation: University of Liège

Abstract: Due to an ill-depicting model of the convective layers below the photosphere, a well-known deviation appears between observed and theoretical frequencies; the so-called surface effects. Alongside, convection also impacts the damping rate of the modes and represents an important part of the driving mechanism behind the oscillations of low-mass stars. With the increasing observational capabilities at our disposal nowadays (Kepler and TESS), this constitutes the main limitations to accurate seismic probing of those stars. In this talk, we present a new formalism which consists in an original non-adiabatic 3D time-dependent convection model for asteroseismology. We aim at keeping the entire 3D structure of the flow in these superficial layers to fully account for the nature of turbulence via the use of hydrodynamic simulation CO5BOLD. We bring forward a new formalism describing standing waves in 3D which is set to solve the global non-adiabatic oscillation equations in a full 3D framework. We show the importance of working in a 3D space and present some preliminary results of the model: the impact of this 3D structure on modes frequencies and damping rates alongside the computation of 3D eigenfunctions. We discuss the impact of the main hydrodynamic simulation characteristics on our results. Finally, we show how our formalism is able to precisely locate regions of driving/damping of the modes in this 3D environment and detail the different physical contributions to the damping.

[Contributed] CT8.4

Title: Stellar Characterisation using Single Value Parameter Method

Author: Nuno Moedas
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Co-authors: Diego Bossini (1,2); Morgan Deal (3)
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Abstract: A star born with a specific composition will not keep it during its evolution. It changes not only with the nuclear reactions, but also due to the chemical transport mechanisms that modify the complete distribution over time. Atomic diffusion is one of the main transport processes taken into account in stellar models, and it can be divided into two main processes, gravitational settling and radiative accelerations. These two processes are in competition, but are neglected in F-type and more massive stars because they produce chemical over-variations at the stellar surface that are unrealistic. Moreover, the current method of calculating radiative acceleration is very computationally expensive and does not allow it to be included in every stellar model. In order to improve and include radiative accelerations in the stellar models, we have implemented a new calculation method in MESA, the Single Value Parameter (SVP). SVP is a more efficient way of calculating radiative accelerations and allows a large number of stellar models to be calculated. Using these new stellar models, we built a stellar grid and used it to characterise a Kepler sample. We show that systematics of up to 5%, 3% and 30% in the inferred mass, radius and age of F-type stars are obtained when chemical transport mechanisms are neglected. These models are a step toward a more accurate understanding and characterisation of F-type stars.

Session 9: Solar-like oscillators

[Contributed] CT9.1

Title: Massive characterization of subgiants and red giants with TESS and Gaia

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Abstract: TESS serves as a formidable tool for investigating stellar variability. Nonetheless, the adaptation of methodologies employed in other space missions, such as Kepler, to deduce long stellar rotation periods or solar-like stellar pulsations has been a challenge. The advent of multiple sectors of data for most stars every two years with the extended TESS mission, alongside enhanced stability, and the introduction of newly calibrated datasets like the Quick Look Pipeline (QLP), has significantly improved this situation. This presentation aims to describe our calibration of TESS light curves, starting from QLP raw flux and employing the Py-TADACS software --a Python package based on the Kepler asteroseismic optimized KADACS software—allowing us to dramatically improve the extraction of low-frequency signals for surface rotation and seismology. In this talk, our primary focus will be the determination of surface gravities (or nu_max) of several hundred thousand of subgiants and red giants (including super-luminous ones) through the utilization of the machine learning FliPer metric as well as Py-A2Z. We will then present the comparison of our findings with previous investigations and Gaia DR3, discussing our yield statistics, problems encountered (pollution, binarity…), and future prospects in light of the PLATO mission.

[Contributed] CT9.2

Title: Testing the wavelength dependence oscillations and granulation in red giants using Kepler and TESS

Author: Sreenivasan Kalarickal Ramachandra
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Abstract: We have developed a new and fast method for measuring nu_max and the amplitude of oscillations. Unlike most other pipelines, we do not fit the granulation background. Instead, we simply divide the power spectrum by a function of the form nu^−2 and then smooth heavily to measure nu_max (Sreenivas et al., 2024). This procedure is able to measure oscillations in 99.9 percent of the 16,000 previously studied Kepler red giants, showing its ability to handle large datasets with low computational cost. On comparing the seismic radii from this work with Gaia, we see similar trends to those observed in previous studies. Additionally, our method can clearly identify the dipole-mode suppressed stars as a distinct population, and hence provide an efficient way to detect them. We also apply this method to red giants observed by TESS. These include about 6000 of the Kepler red giants, as well as many thousands of brighter red giants in the TESS Continuous Viewing Zones (CVZs). We compare the amplitudes of oscillation and granulation in TESS and Kepler to measure the wavelength dependence, which is important information for the upcoming Roman mission (which will observe in the near infrared). We investigate how the method used for light curve extraction affects the amplitudes we observe, and we define metrics to indicate significant detection of oscillations in low signal-to-noise cases.

[Contributed] CT9.3

Title: Unveiling complex magnetic field configurations in red giant stars

Author: Lisa Bugnet
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Co-authors: Srijan Bharati Das (1,2); Lukas Einramhof (1)
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Abstract: Magnetic field configurations are the missing key to unlocking our understanding of angular momentum transport inside stars. Recently, strong radial magnetic fields have been unveiled in the radiative interior of red giant stars. However, the full topology of internal magnetic fields remains a mystery, due to the degeneracies of the signature of various magnetic field configurations on asteroseismic data, strongly impacting our ability to evaluate the impact of magnetism on angular momentum transport. We investigate how complex magnetic field structures, similar to those observed at the radiative surface of intermediate-mass main-sequence stars, can be probed in the interior of red giants. To do so, we demonstrate the complementary sensitivity of dipolar and quadrupolar oscillation modes to the complexity of the magnetic field topology. In addition, we discuss how an inclination of the star's rotation axis compared to our line of sight affects the visibility of the magnetic signature in asteroseismic data. This magnetically induced visibility modulation, along with the intrinsic nuances of disentangling the signatures of a dipolar field from that of higher multipoles (such as a quadrupole), makes the characterization of magnetic field configurations an outstanding challenge. Probing magnetic field topologies inside the core of red giants from such a combined study of dipolar and quadrupolar oscillation modes would revolutionize the current global picture of stellar evolution.

[Contributed] CT9.4

Title: Theoretical analysis of the mixed modes pattern of low-mass core-helium burning stars

Author: Lucy Panier
Affiliation: Space Sciences Doctoral College, ASTA group, University of Liège

Co-authors: Gaël Buldgen (1); Marc-Antoine Dupret (1); Arlette Noels (1); Richard Scuflaire (1)
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Abstract: In recent decades, the availability of high-quality data from space missions such as CoRoT, Kepler and TESS has made asteroseismology a powerful tool for probing the internal structure and dynamics of stars, particularly highlighting its efficiency in analyzing the rich seismic spectra of red giants (Bedding, T. et al. 2011). However, despite the amount of observations, the complexity of the oscillation spectrum of core Helium burning red giants leads to a lack of detailed studies of these promising stars. Computing suitable models for asteroseismic applications during this evolutionary phase presents challenges, notably due to the presence of abrupt changes in the structure of the inner core (Vrard et al. 2022) and the semi-convection problem (see e.g. Salaris & Cassisi 2017). Therefore, additional mixing processes such as convection overshooting and semi-convection are yet to be characterized with all the power of asteroseismic analyses (Bossini et al. 2015). In this context, we conduct a detailed analysis of these stars and investigate their mixed-mode oscillation spectra using the Liège adiabatic oscillation code (LOSC, Scuflaire et al. 2008) and a new version of the Liège stellar evolution code (CLES, Scuflaire et al. 2008) including a precise and consistent treatment of the semi-convective layer and the discontinuity generated by the increase in mass of the mixed region. We aim to establish connections between their seismic properties and internal chemical composition.

[Contributed] CT9.5

Title: Study of convection and nuclear reactions through ensemble Red Clump stars seismology

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Abstract: Stars in the Red Clump (RC) are high-metallicity, low-mass, core-helium burning stars which went through the He-flash. They are astrophysically important, since they can be used as standard candles that trace the chemical evolution of the Galaxy. Yet, due to the many uncertainties associated with the physical processes that happen during the helium flash, as well as in the central regions of RC stars, modelling these stars is particularly challenging. In this work, we use asteroseismology to constrain these processes, with a focus on nuclear reactions and convection. RC stars are solar-like oscillators and exhibit mixed modes, whose period spacing is a very good probe of the properties of the region around the convective core. We performed an ensemble seismic study of the RC stars observed by Kepler and compared the observed period spacing distribution to a simulated distribution. This simulated distribution incorporates the mass as well as the metallicity distribution of the observed stars; for this we use models computed with the MESA stellar evolution code. These comparisons allow us to test different prescriptions of core boundary mixing, as well as different values of carbon-alpha nuclear reaction rate. Notably, we find that assuming mode trapping in the semiconvective region as well as a nominal, or slightly higher, carbon-alpha nuclear reaction rate yields a period spacing distribution that is compatible with that of observations.

[Contributed] CT9.6

Title: Semi-analytical models of core-helium-burning stars: Structural glitches near the core

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Abstract: The advent of the space mission Kepler has allowed for a detailed study of the oscillation spectra of numerous red giant stars, providing insight into their internal structure, global properties, and evolutionary phase. In particular, mixed pressure-gravity modes enable us to probe structural variations (glitches) in the inner radiative regions near the core of low-mass, core-helium-burning (CHeB) stars. These glitches may be related to temperature and chemical-composition stratification of the convective boundary layer, as well as the number and location of helium-flashes, and their impact on frequencies is complex. To develop robust seismic indicators we need models that are free from glitches related to numerical issues and that allow us to investigate sharp-structural variations that affect buoyancy frequency profiles. In this work, we develop semi-analytical models of CHeB solar-mass stars, calibrated using the evolutionary codes CLES and MESA. With this tool we can add structural variations more quickly and numerically more accurately than using evolutionary codes. Specifically, we investigate changes in frequencies and period spacing resulting from discontinuities in the density profile. For instance, we find that a sharp density variation in the radiative core of CHeB stars creates a clear structure in the period spacing resembling a double g-mode cavity. Such patterns can be used to develop robust signatures of mixing occurring near the core of such stars.

Session 10: AF stars

[Invited] IT10.1

Title: Pulsations in A and F type stars: challenges and prospects

Author: Konstanze Zwintz
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Abstract: A and F stars are exceptional laboratories characterized and shaped by a large diversity of physical processes acting in them. These processes include varying rotational speeds, a wide range of chemical compositions, and magnetic fields and activity resulting in spots on the stellar surfaces. Pulsating A and F type stars can be found in very different evolutionary stages as well - from the pre-main sequence to the ZAMS and up to the post-main sequence phases - which corresponds to quite different interior structures. Asteroseismic analyses of A and F stars are challenged by the interplay of these physical processes. But at the same time this diversity provides ideal conditions for advancing our knowledge of stellar physics and is crucial for refining models of stellar evolution. In this presentation, I will review recent findings from studies on A-F pulsators and address key challenges that still hinder our complete understanding of these stars.

[Contributed] CT10.1

Title: HD 60435: The star that stopped pulsating

Author: Donald Kurtz
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Abstract: Stellar pulsation is ubiquitous across the HR Diagram, occurring in many classes. A given star may pulsate as different kinds of variables during its lifetime, as it evolves into and out of various pulsational instability strips or regions in the HR Diagram. What causes the growth and decay of some pulsation modes on very short timescales (compared to evolution) is not known. HD 60435 is a well-studied roAp star that pulsates in a series of high-overtone dipole and quadrupole modes, making it an excellent asteroseismic target. It has been observed by TESS between Sectors 3—69 giving detailed observations of the mode amplitude behaviour. Some modes show strong amplitude modulation on a time scale of 1 day, and, most remarkably, the star ceased pulsating completely from Sector 33. No other star has been observed to do this. We have extracted pulsation frequencies during times the star was pulsating and used those for asteroseismic modelling, suggesting that the star is a globally low-metallicity subgiant. Some dipole modes are occasionally stable enough over two rotation periods to extract the pulsation geometry using the oblique pulsator model. We model one quadrupole mode that is strongly distorted by the magnetic field, similar to several other roAp stars. It will be interesting to see if HD60435 resumes pulsating in the future.

[Contributed] CT10.2

Title: Measuring core rotation in gamma-Dor stars from dips in the gravity-mode period spacing pattern

Author: Lucas Barrault
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Abstract: Asteroseismology provides unique tools to constrain the transport of angular momentum throughout stellar evolution, a major caveat in stellar modeling. Dips in the gravity modes period spacing vs period diagram of gamma-Dor stars, already proven to form from the chemical discontinuities in the radiative zone, were also demonstrated to arise from the interaction of gravito-inertial modes in the radiative zone with pure inertial modes in the convective interior of gamma-Dor stars. The analysis of these mixed modes brings unprecedented insights into the convective interior. The inertial dip formation has been described by Tokuno & Takata 2022 and the Lorentzian shape of the dip is derived analytically for Kelvin modes, with a solid-body rotation. We aim to extend the formalism developed in this pioneering work to the case of a two-zone rotation profile, and investigate the detectability of such differential rotation inside gamma-Dor stars. We solve the coupling equation numerically, further compared to an analytical derivation of the Lorentzian profile. We investigate the detectability of radial differ- ential rotation in Kepler data. We show that, with an increasing differential rotation rate from envelope to core, the dip gets shifted to low periods, and gets deeper and thiner. Studying the dip structure and location in asteroseismic data might allow to access radial differential rotation and better understand the transport of angular momentum in main-sequence stars.

[Contributed] CT10.3

Title: Achieving non-linear models for Delta Scuti stars

Author: Miriam Rodríguez Sánchez
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Abstract: Complete codes describing the oscillations inside a star have always been a major problem to achieve due to the complex physics related to oscillations, especially for Delta Scuti which are known for their rich power spectrum. Non-linear models are scarce, far from being complete and have focused on Cepheids and RR Lyrae In this abstract, we describe the current progress in the development of a complete nonlinear code for solving the equations of oscillations. The nonlinearized equations of oscillation have been derived from the fundamental equations of hydrodynamics by developing them up to second order in perturbations in terms of the displacement vector. The scheme presented in Unno et al. (1979) and Aerts et al. (2010) was followed assuming no rotation, no magnetic fields, no viscosity, no adiabaticity and no turbulent convection Some challenging cross-terms appeared which prevented us from solving the equations numerically in the classical way of separating the equations into two independent (radial and horizontal part) To address this, we adopted the following strategy: Solve the classical set of linear adiabatic equations;Evaluate the non-linear terms; Analyse the results to distinguish those that were essential and which were not and finally, the equations will be solved with the most significant terms In summary, this is a remarkable approach to the long sought-after nonlinear models that will allow to further understanding of the complicated physics of pulsations

[Contributed] CT10.4

Title: Exploring the Origins of the Spike Feature in HR 7495: Stellar Spots or Overstable Convective Modes?

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Abstract: Over 200 A and F type stars observed with Kepler show a unique "hump & spike" feature in their Fourier spectra, with the "hump" linked to unresolved Rossby modes and the "spike" to stellar spots or Overstable Convective (OsC) modes. This study investigates the origins of the spike in these stars, focusing on HR7495, the brightest among them for which we analyse Kepler and TESS photometric data, along with radial velocity and spectropolarimetric data. Our findings indicate that the spike characteristics align with surface rotational modulation by stellar spots, despite the absence of significant magnetic fields. This suggests the presence of a subsurface convective layer operating a dynamo, producing low-amplitude magnetic fields with complex geometries. Overall, the data support the hypothesis that all "hump & spike" stars, likely harbour an undetected weak magnetic field driven by a dynamo mechanism.

Session 11: OB stars

[Invited] IT11.1

Title: Main Sequence OB "Classical" Pulsators

Author: Jonathan Labadie-Bartz
Affiliation: Paris Observatory

Abstract: Among the OB stars, the two most well known classes of pulsators are Beta Cephei stars (with pressure modes) and Slowly Pulsating B (SPB) stars (with gravity modes). There are, however, other distinct types of pulsation, including tidally-induced modes, Rossby waves and inertial modes in rotating stars, and stochastic low-frequency variations. These phenomena are not in general mutually exclusive, providing several avenues for probing the physics of OB stars from the core to the surface. Asteroseismology of OB stars has largely lagged behind the intermediate- and lower-mass stars for practical reasons, including their relative rarity, being disfavored by exoplanet searches, and having a fundamentally different structure than the Sun. Progress in this field has accelerated, in large part thanks to the all-sky coverage of TESS. Now with a solid foundation, OB star seismology is poised to expand to larger sample sizes while including more complex physics such as rapid rotation, tidal forces, and magnetism. This will be enabled by longer-baseline space photometry (e.g. in the TESS CVZ and the soon-to-be-launched PLATO mission), dedicated ground-based observing efforts, and new developments in models and theory. Continuing on this path promises to significantly improve our understanding of massive star structure and evolution, with wide impacts on topics such as population studies, chemical enrichment, supernovae, and the end products of stellar evolution.

[Contributed] CT11.1

Title: 3D Simulations on the Evolution of Magnetic Fields in Massive Stars

Author: Rathish Ratnasingam
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Abstract: We present 3D global simulations of a 7 solar mass star, wherein a convective core generates internal gravity waves that propagate through the radiative envelope. These simulations feature an imposed large-scale dipolar magnetic field, with a convective core dynamo generating a more complex magnetic field. Our study aims to investigate the evolving core dynamo's impact on magnetic field strength and geometry at the core-envelope boundary, as well as its effect on internal gravity wave generation and propagation. Insights gained from this investigation can enhance current analytical and observation models probing interior magnetic fields, and provide valuable numerical data for coupling with surface variability observations.

[Contributed] CT11.2

Title: Merger seismology: asteroseismic properties of massive merger products

Author: Jan Henneco
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Abstract: Products of stellar mergers are likely common in stellar populations and can potentially explain stars with peculiar properties. Massive post-main-sequence (post-MS) stellar merger products may remain on the blue side of the Hertzsprung gap (HG) for millions of years and, hence, provide a natural explanation for the overabundance of observed B-type stars. Distinguishing merger products from genuine single stars (GSSs) based on surface diagnostics alone is not straightforward. We make model-by-model asteroseismic comparisons between massive post-MS merger products and GSSs to identify which asteroseismic diagnostics can be used to distinguish them. Merger products on the blue side of the HG have convective He-burning cores, while GSSs (M < 11.4 Msol) with similar surface diagnostics are fully radiative. As a result, merger products have significantly lower asymptotic period spacing values. The presence of a convective H-burning shell in merger products causes the appearance of deep dips in their period spacing patterns (PSPs). GSSs of >11.4 Msol have a short-lived intermediate convective zone, which causes similar deep dips in their PSPs. We perform these comparisons with and without the effects of slow rotation included in the pulsation equations and conclude that the two types of stars are seismically distinguishable in both cases. The observability of the distinguishing asteroseismic features of merger products can now be further assessed and exploited in practice.

[Contributed] CT11.3

Title: First direct modelling of gravito-inertial tidally excited non-adiabatic oscillations

Author: Fellay, Loïc
Affiliation: University of Liege

Co-authors: L. Fellay (1) & M.-A. Dupret (1)
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Abstract: The last few years have seen the first detection of tidally excited stellar oscillations (TEO) in multiple star systems opening new opportunities to study the physics of stars, understand their structural properties and their evolution. From a theoretical standpoint, current models cannot consistently treat impact of stellar rotation on TEOs. The modelling of the impact of the Coriolis force on low frequency free oscillations is usually done with the so-called traditional approximation. In this approximation, the effect of the radial component of the displacement on the horizontal component of the Coriolis force is neglected along with the radial component of the Coriolis force (Unno et al. 1989). This approximation is usually used coupled to the Cowling approximation which neglect the potential perturbation as the Poisson equation. In the case of TEOs, having a consistent treatment of the potential perturbation is essential as the orbital migration, eccentricity variation and all the orbital effects caused by the TEOs (called dynamical tides in this context) are proportional to the imaginary part of the potential perturbation. In this talk, we present a new methodology to include the Coriolis force in the modelling of TEOs through the traditional approximation but consistently treating the potential perturbation by iteratively solving the Poisson equation following the direct simulation approach. We will also discuss the case of tidally excited Rossby modes.

[Contributed] CT11.4

Title: TESSting the waters: Blue Super Giants as viewed by TESS

Author: Cole Johnston
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Co-authors: Cole Johnston (1,2), Linhao Ma (3), Selma de Mink (1), Earl Bellinger (4), Stephen Justham (1)
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Abstract: The observed abundance of blue super giants (BSGs) presents a challenge to state-of-the-art stellar evolution codes. One particular challenge for theoretical models is understanding the formation channels that produce BSGs, and whether they are the products of single star evolution, binary mass transfer, or even stellar mergers. The probing power of asteroseismology promises to reveal the internal structure of BSGs, should coherent pulsations be robustly identified and modeled. Over the past 18 years, there has been substantial theoretical work demonstrating that BSGs should exhibit p and g-mode oscillations. More recent theoretical work has shown that standard asteroseismic diagnostics can differentiate between BSGs formed through single star evolution or through merger scenarios. Concurrently, there has been much debate about the presence of stochastic low-frequency (SLF) variability in BSGs observed by TESS, the interpretation of this signal, and its source. In this talk, we build on the recent work by Ma et al. 2024 to demonstrate that there is a clear power excess observed at low frequencies in most BSGs, that was previously interpreted as SLF. We discuss the observational characterisation of this power excess, and its implications for understanding the SLF. Finally, we discuss the opportunity for asteroseismic analysis and its probing power for internal structure, as well as for the origin of BSGs.

Session 12: Galactic archaeology

[Invited] IT12.1

Title: Galactic Archaeology

Author: Amina Helmi
Affiliation: Kapteyn Astronomical Institute

Abstract: I will review our current understanding of the early history of the Milky Way, with particular focus on the discovery and characterization of its building blocks. I will discuss the lessons learned using dynamical, chemical and star formation perspectives, all of which have been made possible by Gaia together with various ground-based spectroscopic surveys.

[Contributed] CT12.1

Title: Tracing the Milky Way's Journey Through Time

Author: Giada Casali
Affiliation: Australian National University

Co-authors: Josefina Montalbán (1), Andrea Miglio (1)
Co-authors affiliation: Università di Bologna (1)

Abstract: In the era of large spectroscopic surveys, high-quality spectra can contribute to understand how our Galaxy formed and evolved until the present-day structure, not only providing high-precision abundances of elements belonging to the different nucleosynthesis channels, but also giving constraints to one of the most elusive quantities in astrophysics, stellar age. Some abundance ratios, called chemical clocks, have proved to be excellent indicators of stellar age. We can distinguish them in: ratios composed by elements which vary during stellar evolution, [C/N], or ratios that are modified by the Galactic chemical evolution, see [Y/Mg]. In this talk, I aim at describing our method to calibrate empirical relations between chemical clocks,[Fe/H] and ages, using stars with age from asteroseismology present in the large spectroscopic surveys as calibrators. Finally, I will briefly show how high-quality spectra (HARPS-N@TNG, FIES@NOT) of a sample of 68 Kepler stars, of which we know high-precision ages from asteroseismology using individual mode frequencies, can enhance our ability to calibrate stellar age-chemistry relationships using chemical clocks. The orthogonal constraints offered by age from asteroseismology, precise chemical composition from ground-based high-resolution spectroscopy, and dynamics from the Gaia mission open the door to a more accurate understanding of the chemical evolution of the Galactic disk, tracing the processes of chemical enrichment with time.

[Contributed] CT12.2

Title: Dissecting Stellar Populations with Manifold Learning

Author: Andreas Wilhelm de Barros da Silva Neitzel
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Abstract: Stellar populations distinguish themselves from one another via differences in chemical, kinematic and chronological properties, suggesting an interplay of different physical mechanisms that led to their origin and subsequent evolution. As such, the identification of stellar populations is key for gaining insight on the evolutionary history of the Milky Way galaxy. This task is made complicated by the fact that stellar populations share significant overlap in their chrono-chemo-kinematic properties, which hinders the ability to both identify and define stellar populations. To tackle this problem, we explore use cases of manifold learning, a type of unsupervised machine learning application which seeks to intelligently identify and disentangle manifolds hidden in the input data. To test the method, we make use of Gaia DR3-like synthetic stellar samples generated from the FIRE-2 cosmological simulation. We show that manifold learning possesses promising abilities to differentiate stellar populations, even when considering realistic observational constraints.

[Contributed] CT12.3

Title: Towards a new RGB mass-loss law

Author: Karsten Brogaard
Affiliation: Stellar Astrophysics Centre, Aarhus University

Co-authors: Andrea Miglio (1), et al. (1)
Co-authors affiliation: (1) Department of Physics & Astronomy, University of Bologna, Via Gobetti 93/2, 40129 Bologna, Italy

Abstract: We use quasi mono-age mono-metallicity populations of field stars from the Milky Way high-alpha sequence with asteroseismic measurements from the Kepler and K2 missions and spectroscopic data from APOGEE DR-17. We derive integrated RGB mass-loss at different metallicities and corresponding median masses and find a mass-loss dependence on metallicity and/or mass. We compare this dependence to expectations from the Reimers mass-loss law or assuming the mass-loss is driven by solar-like oscillations. To expand the mass and metallicity baseline further, we include also the asteroseismic integrated mass-loss in open and globular clusters from previous works. We might be on the right path towards a new RGB mass-loss law that does not require a recalibration for different populations.

[Contributed] CT12.4

Title: Age-dating α-element Enhanced Stars in the Galactic Halo with Asteroseismology

Author: Christopher Lindsay
Affiliation: Yale University

Co-authors: Sarbani Basu (1); Joel Ong (2)
Co-authors affiliation: (1) Yale University; (2) University of Hawaii

Abstract: The formation of the Milky Way's stellar halo is believed to have occurred via the accretion of smaller dwarf galaxies, yet the precise timing of these events remains uncertain. A promising avenue to age-date these merger events relies on combining spectroscopic and asteroseismic data of some of the old, metal-poor stars associated with the progenitor galaxies to determine stellar ages using both isochrone fitting and asteroseismology. An important complication in this technique arises due to the fact that old metal-poor stars are overabundant in α-elements. Often these stars are modeled using an ad hoc correction to the total metallicity of the stellar models, which allows models to fit the position of stars in the HR diagram. With seismic data of nearby stars now available from Kepler and TESS, we are now in a position to more precisely determine the properties of these α-enhanced stars. We show that implementing the correct treatment of α-enhancement decreases the inferred asteroseismic age, based on a seismic reanalysis of the naked-eye star ν-Indi using updated mode frequencies from combined TESS observations at 120 second and 20 second cadence. We also investigate how other modelling choices, such as extra mixing at convective boundaries, alters the asteroseismic modelling results.

Session 13: Exoplanets and Binaries

[Invited] IT13.1

Title: Exoplanet Atmospheres

Author: Ian Crossfield
Affiliation: University of Kansas

Abstract: An exoplanet's overall composition is presumably determined by its formation, accretion, and migration history. Observing a planet's atmosphere provides the best hope for distinguishing the makeup of its outer layers, and the only hope for understanding the interplay between initial composition and present-day chemistry, dynamics & circulation, and disequilibrium processes. Interpretation of a planet's spectrum is far easier when the planet has a known mass and radius. JWST is now the world-leading facility for exoplanet atmospheric characterization, and offers one of the most promising avenues for revealing the exoplanet atmospheric compositions. Although numerous atmospheres have been probed by HST and ground-based observations, a major breakthrough is underway thanks to the increased sensitivity and wavelength coverage of JWST. This talk will review recent results and open questions in the field of exoplanet atmospheres, with a particular focus on JWST's latest discoveries and how these are complemented by ongoing TESS observations.

[Contributed] CT13.1

Title: Chemically Depleted Stars Are Magnetically More Active: A Possible Planet Formation Imprint

Author: Jie Yu
Affiliation: Australian National University

Abstract: Theoretical studies predict that exoplanet formation may induce chemical depletion in host stars compared to those without planets, whereas exoplanet engulfment could enrich stellar chemistry. Nonetheless, the relationship between these exoplanet signatures and stellar chemical anomaly has remained a subject of ongoing debate. Here, we tackle this open question from a novel perspective: magnetic activity. Specifically, we investigate homogeneous, high-precision, differential chemical abundances of 125 co-moving star pairs using spectra obtained from the Magellan, Keck, and VLT telescopes through the C3PO program. Each of these systems comprises a pair of reference and target stars that share similar fundamental properties at young ages (typically 3.2 Gyr). Among the systems with chemical anomalies, we identify a clear pattern: their chemical abundance differences are inversely correlated with differential magnetic activity derived from Ca II infrared triplets. Furthermore, the significance of this inverse correlation increases with condensation temperature. While alternative mechanisms cannot be entirely ruled out, our analysis suggests that exoplanet formation is likely the principal driver of these observed trends. Our findings regarding magnetic activity offer new insights into the origin of chemical anomalies present in exoplanet host stars.

[Contributed] CT13.2

Title: Characterizing the variability of a sample of massive pulsators in eclipsing binaries

Author: Christian Ikechukwu Eze
Affiliation: Nicolaus Copernicus Astronomical Center, Warsaw, Poland

Co-authors: Gerald Handler (1); Filiz Kahraman Alicavus (2); Tilaksingh Pawar (3); Amadeusz Miszuda (1)
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Abstract: Massive stars exhibit a perplexing mismatch between their inferred masses from different observational techniques, posing a significant challenge to our understanding of stellar evolution and structure. This discrepancy is believed to be caused by the underestimation of the convective core masses. The efficiency of such measurement is usually impaired by a lot of processes at work in the interior of the stars such as convective core overshooting and interior rotation. By integrating the precision of Asteroseismology which provides insights into the internal structure and dynamics of stars, with the detailed observational constraints offered by eclipsing binary systems, this study aims to precisely characterize a sample of massive pulsators in eclipsing binaries to infer their properties and evolutionary state. In this paper, a sample of ten massive pulsators in eclipsing binary systems observed photometrically with TESS and spectroscopically with SALT and CHIRON between 2021 and 2023 are analyzed. The orbital elements as well as the basic stellar parameters of the targets in the sample are fitted to derive the geometry of their orbits as well as their absolute parameters. The asteroseismic properties of the targets are also obtained, which unravel their core dynamics and profiles. This is a precursor work that provides detailed characterization of the targets in the sample for future theoretical modeling.

[Contributed] CT13.3

Title: Tackling the complexities of overlapping oscillations in asteroseismic binaries using Kepler data

Author: Jeong Yun Choi
Affiliation: Heidelberg Institute for Theoretical Studies (HITS)

Co-authors: Francisca Espinoza (1); Quentin Coppée (1); Saskia Hekker (1)
Co-authors affiliation: (1) Heidelberg Institute for Theoretical Studies

Abstract: Asteroseismic binaries are defined as single light curves including two oscillation patterns. Predictions indicate that approximately 200 red-giant asteroseismic binaries could be present among the roughly 20,000 red giants observed by Kepler (Miglio et al. 2014). However, detecting such systems becomes particularly challenging when the binaries exhibit overlapping oscillation spectra. To address this challenge, we created thousands of synthetic asteroseismic binaries by combining the KASOC light curves of two individual red giants. We investigated how their oscillation modes interact and superpose when including stars with different evolutionary stages, brightness, and frequency at maximum oscillation power (numax). We then categorised these synthetic complex power spectra to identify unique characteristics, such as entangled shapes of non-radial modes, irregular oscillation behaviours, and intricate mode interactions. We discuss a deeper understanding of the nature and detectability of asteroseismic binaries with complex features, offering insights into stars that were so far not understood.

[Contributed] CT13.4

Title: A seismic study of the benchmark red-giant binary system KIC 9163796

Author: Desmond Grossmann
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Co-authors: Desmond Grossmann (1,2), Paul Beck (1,2), Savita Mathur (1,2), Cole Johnston (3), Joel Zinn (4), Santi Cassisi (5), Carlos Allende (1,2), Rafael Garcia (6), Bastien Liagre (6), Diego G. Rivira (1,2)
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Abstract: The age of a star cannot be measured but only inferred from observational quantities related to age. For stars in the red-giant phase, classical methods such as isochrone fitting can deliver ages with statistical uncertainties between 30 and 50 %. Asteroseismic modeling is known to provide the most precise ages for red giants to date. Furthermore, modeling the observables provided by double-lined spectroscopic (SB2) binaries enables us to test the input physics and break parameter degeneracies. Combining asteroseismic constraints with those from dynamics offers a unique opportunity to improve the stellar parameters as well as the age of the system. In this talk, we present the results of the in-depth modeling analysis of KIC9163796, an oscillating sub-giant & red-giant SB2 binary system with almost identical masses, but both components at significantly different positions on the HRD. Using a multi-dimensional grid computed with the stellar evolution code MESA, we modeled both binary components with different sets of observables. By exploiting the constraints from binarity, we test for the effect of the mixing length parameter, initial helium, and the inclusion of the global seismic parameters on the joint-stellar evolution. This yields an age estimation for the binary system of ~2 Gyrs. We show that by combining asteroseismic and binarity constraints, the age uncertainty obtained from stellar modeling can be significantly decreased.

Session 14: Galactic archaeology

[Contributed] CT14.1

Title: An Asteroseismic Age for an Ancient Very Metal-Poor Star

Author: Dan Huber
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Abstract: Very metal-poor stars ([Fe/H] < -2) are important laboratories for testing stellar models and reconstructing the formation history of our galaxy. Asteroseismology is a powerful tool to probe stellar interiors and measure ages, but few asteroseismic detections are known in very metal-poor stars and none have allowed detailed modeling of oscillation frequencies. We report the discovery of a low-luminosity Kepler red giant with high S/N oscillations, [Fe/H]=-2.7 and [alpha/Fe]=0.4, making it by far the most metal-poor star to date for which detailed asteroseismic modeling is possible. We combine spectroscopy with Kepler to model the oscillation spectrum to derive a precise asteroseismic mass and age, finding remarkable agreement across different codes and input physics, which demonstrates that stellar models and asteroseismology are reliable for very metal-poor stars when individual frequencies are used. The results also provide a direct age anchor for the early formation of the Milky Way, implying that substantial star formation did not commence until redshift z~3 (if the star is part of the ancient galactic disc) or that the Milky Way has undergone merger events for at least ~12 Gyr (if the star was accreted by Gaia Enceladus).

[Contributed] CT14.2

Title: Exploring the Galactic helium enrichment law

Author: Amalie Stokholm
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Abstract: The Galactic helium enrichment law , which enters and affects the inference of stellar properties, is uncertain. The helium enrichment law is typically assumed to be a static, spatially universal, and linear relation of initial helium to initial metallicity, however, the gradient shows great variances across the literature. With recent advances in modelling stars using high-precision asteroseismology, the effects associated with our assumptions of stellar helium abundance have become more and more obvious as it can result in inaccurate inference and systematics on the inferred stellar parameters. This is a great challenge for the field of Galactic archaeology where the link between stellar ages and chemical signatures is explored. We have developed a hierarchical Bayesian model (HBM) to encode information from asteroseismic red stars belonging to the Galactic thick disk to study the helium enrichment law across the Galactic disk more fully. By using all the available population-wide information, we investigate the variance of the helium enrichment law across Galactic positions and the HBM allows us to do statistical tests of this hyperparameter more fully than if we only used the information from a star-to-star analysis. Our HBM can also be applied to greater samples such as the Gaia thick disk sample using the calibration from the asteroseismic sample which will lead to improved constraints on both the population-level inference and the star-by-star fundamental parameters.

[Contributed] CT14.3

Title: A new view of Galactic discs : unveiling precise ages with individual oscillation modes

Author: Andrea Miglio
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Abstract: To understand the intricate processes shaping the Milky Way's current appearance, precision in age determination is paramount. While Gaia data have facilitated the dating of rapidly evolving phases like subgiants, the limitations posed by their intrinsic luminosity prompt the exploration of alternative stellar types. Red giants, extending our reach to more distant galactic regions and covering a broad age domain, represent ideal tracers of the Galaxy's structure and evolution. Conventional age-dating techniques for red giants are, however, highly degenerate. CoRoT, Kepler and TESS have lifted this limitation, and enabled us to infer masses of red giants, and thus their ages. Combining average seismic parameters with spectroscopic and astrometric data allowed us to reach an age precision on the order of 20-25% elucidating, e.g., the age spread of the high-alpha population. In this work we push the limits of age precision further by exploiting individual oscillation modes measured in about 3000 red-giant-branch stars in the Kepler field observed by APOGEE and Gaia. Following the approach we developed to age-date stars belonging to Gaia-Enceladus, we infer ages with a precision ~ 10-15%, nearly a factor two better compared to previous studies of the galactic discs using seismology of red giants. We will discuss how this improved temporal resolution gives us a sharper view on the formation and chemo-dynamical evolution of the Milky Way at early epochs.

[Contributed] CT14.4

Title: Traveling Back In Time: Asteroseismic Ages of TESS's Low-Metallicity Red Giants

Author: Corin Marasco
Affiliation: University of Florida

Co-authors: Corin Marasco (1); Jamie Tayar (1)
Co-authors affiliation: (1) University of Florida

Abstract: Galactic archeology has long been limited by a lack of precise masses and ages for metal-poor stars in the Milky Way's thick disk. However, with TESS providing a growing number of photometric observations, it is possible to calculate such physical properties for more solar-like oscillators than ever using asteroseismology. We have used the pySYD pipeline to determine global asteroseismic parameters and calculated the masses and ages of 415 metal-poor ([M/H] $<$ -0.5) red giants in TESS's continuous viewing zones. Our findings contribute to a noticeable trend in metallicity-dependent mass loss on the upper red giant branch and identify a set of young high-α stars that have been detected in other studies. We also find that 15\% of the metal-poor stars appear to be binary merger products. In combination with existing ages from Kepler/K2, this data can be compared to galactic evolution models to better determine the formation history of the galaxy.

[Contributed] CT14.5

Title: KIC10001167: The prototype eclipsing binary for red giants in the old in-situ Milky Way population

Author: Jeppe Sinkbaek Thomsen
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Abstract: The study of global, resonant oscillation modes in low-mass red giant branch (RGB) stars enables age inference of unprecedented (~10%) precision. This offers the possibility to reconstruct the temporal evolutionary history of the Milky Way (MW) at early cosmic times. Ensuring the accuracy of such a precise age scale is a fundamental challenge. Since the age of RGB stars primarily depends on their mass, a mass determination from an independent source for an oscillating RGB star would allow such an assessment. We will present a <1% precision dynamical mass determination of an RGB member of a detached, double-lined eclipsing binary (EB) system, KIC10001167. From its dynamical mass, spectroscopy and kinematics, we confirm the system as a member of the old in-situ Galactic disk population. This makes it a unique proxy to study its parent population from several avenues simultanously (dynamical, asteroseismic, and spectroscopic). With our dynamical analysis involving completely new high-precision spectra, we resolve the large discrepancy found between previous asteroseismic and dynamical mass determination (Montalban+2021, Gaulme+2016), as we establish a 1% agreement with that of individual oscillation mode inference. We will demonstrate the dynamical and seismic nature of the system, along with several astrophysical limitations and prospects for future studies of it.

[Contributed] CT14.6

Title: An all-sky map of the Milky Way using luminous semi-regular variables

Author: Daniel Hey
Affiliation: University of Hawaii

Co-authors: Daniel Huber (1); Ben Shappee (1); John Tonry (1); Robyn Sanderson (2); Sukanya Chakrabarti (3)
Co-authors affiliation: (1) University of Hawaii; (2) University of Pennsylvania; (3) The university of Alabama in Huntsville

Abstract: The lack of reliable, large-scale stellar distances beyond several kpc means that the structure and kinematics of the Milky Way are largely unexplored. In this talk, we present a method to measure distances of M-giant semi-regular variables using a period-amplitude-luminosity relation anchored to the Large Magellanic Cloud, with random uncertainties of 10–15% and systematic errors below 1–2%. We apply this method to ground-based photometry to measure distances to several million stars in the Milky Way out to 20 kpc, validated with TESS photometry. Using this sample we measure a distance to the Galactic center of R0 = 8108 ± 106stat ± 93sys pc, consistent with astrometric monitoring of stars orbiting Sgr A*. Cross-matching the distances with Gaia we furthermore constrain the Milky Way's velocity field. The results demonstrate that pulsations of M-giant stars are a powerful distance marker to probe stellar populations in our galaxy.

Session 15: AF and OB stars

[Contributed] CT15.1

Title: Peculiar pulsators

Author: Jim Fuller
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Co-authors: Nicholas Rui (1) Rahul Jayaraman (2)
Co-authors affiliation: (1) Caltech (2) MIT

Abstract: With hundreds of thousands of pulsating stars observed by Kepler and TESS, new classes of peculiar pulsators are being found, providing new insights into stellar evolution. One such unusual class are red giants that have formed via stellar mergers. I will discuss the asteroseismic and abundance signatures that can be used to identify red giants formed via mergers between white dwarfs and main sequence stars. Another class are tidally tilted pulsators in close binaries. I will demonstrate that these stars are tri-axial pulsators, such that pulsation modes are aligned with one of the three principal axes of the star, rather than being spherical harmonics. Finally, I will discuss an emerging class of extremely slowly rotating pulsators in close binaries, which can arise from stars that become trapped in an asynchronized Cassini state when they are part of a triple star system.

[Contributed] CT15.2

Title: Probing stellar physics with ensemble studies of Chemically Peculiar stars

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Abstract: Chemically peculiar stars are benchmarks for studies concerning the transport of chemical elements and the interplay between convection and magnetic fields. Until recently, such studies were limited by the small number of known pulsators among chemically peculiar stars as well as by the difficulty in achieving homogeneous determinations of their seismic and non-seismic properties. This has changed drastically over the past few years, with the advent of TESS and GAIA. In this talk we will share the results from the first ensemble study of ~100 pulsating magnetic Ap stars and explore the differences between the pulsation properties in these stars and stars that are similar (the Am stars), but with undetected or weak magnetic fields. Based on adiabatic and non-adiabatic pulsation models we will further show how these pulsation properties can be used to constrain chemical transport inside these stars and learn about the interaction between magnetic field and convection.

[Contributed] CT15.3

Title: TESS light curves of extra-galactic massive stars reveal the origin of stochastic gravity waves

Author: Dominic Bowman
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Abstract: Massive stars are progenitors of neutron stars and black holes, and their winds and explosive deaths provide chemical and radiative feedback to entire galaxies. The convective cores of main-sequence massive stars are engines that drive their evolution, but also excite damped gravity waves that reach the surface to produce stochastic low-frequency (SLF) variability. Gravity waves are efficient at chemical mixing and angular momentum transport in massive star interiors, which remain largely uncalibrated in evolution models. Sub-surface partial-ionisation convection zones can also produce SLF variability in massive stars making it difficult to disentangle the two sources. However, for massive stars in low-metallicity regimes, such as the LMC and SMC, the influence of sub-surface convection zones is expected to be negligible. In this talk, we present our analysis of light curves from the TESS mission extracted using a novel effective point-spread function (ePSF) method, which overcomes the challenge of studying faint and blended stars in the LMC and SMC. The properties of SLF variability in massive stars are consistent across the metallicity range from the Milky Way down to the LMC and SMC. This shows that sub-surface convection, which is strongly dependent on metallicity, cannot be the sole mechanism of SLF variability in massive stars. We conclude by showcasing the potential of using TESS for performing asteroseismic studies of extra-Galactic massive stars for the first time.

Session 16: Compact stars

[Invited] IT16.1

Title: Asteroseismology of compact pulsating stars

Author: Murat Uzundag
Affiliation: KU Leuven

Abstract: Compact pulsating stars, such as hot subdwarfs and white dwarfs, offer the invaluable opportunity to study stellar objects that represent the final stages of evolution for low- and intermediate-mass stars through asteroseismology. Pulsating hot subdwarf and white dwarf stars exhibit brightness variations with pulsation periods ranging from approximately 100 to 14 000 seconds and amplitudes reaching up to 0.4 magnitudes. The most effective method for detecting and analyzing these subtle fluctuations is continuous high-cadence time-series photometry. Over the past decade, space missions such as Kepler, K2, and currently NASA's Transiting Exoplanet Survey Satellite (TESS) have significantly enhanced our understanding of pulsating, highly evolved compact stars. These advancements are driven by improvements in high-precision and high-duty cycle photometric monitoring from space, allowing for highly precise frequency measurements and the use of innovative asteroseismological techniques to study pulsating hot subdwarfs and white dwarfs. In this review talk, I will explore the crucial role of asteroseismology in studying these pulsating compact stars, covering the latest developments in observational techniques and theoretical models that have advanced our understanding of hot subdwarfs and white dwarfs. Additionally, I will highlight the significant contributions of ground-based telescopes and space missions to the field of asteroseismology and consider future prospects that may transform our knowledge of these fascinating stellar remnants.

[Contributed] CT16.1

Title: Kepler and TESS weigh in on the purity of the DAV instability strip

Author: JJ Hermes
Affiliation: Boston University

Abstract: Current theory holds that all hydrogen-dominated (DA) white dwarfs pulsate when they reach the appropriate effective temperature to develop a surface convection zone, starting at roughly 13,000 K. However, even small-scale (tens of kilogauss) magnetic fields can suppress convection effectively enough to prevent the excitation of global pulsations. Kepler and TESS have now surveyed thousands of white dwarfs with enough precision to detect millimagnitude (part-per-thousand) pulsations. I will report on the status of the purity of the DAV instability strip thanks to Kepler, K2, and TESS monitoring.

Session 17: RR Lyrae and Cepheid stars

[Invited] IT17.1

Title: Asteroseismology with low-amplitude modes in RR Lyrae and Cepheids

Author: Emese Plachy
Affiliation: Konkoly Observatory, HUN-REN CSFK

Abstract: RR Lyrae and Cepheid stars have been long believed to pulsate purely in radial modes and thus we are limited to estimate physical parameters photometrically from those modes only. This picture has changed with the discovery of additional periodicities with amplitudes many orders lower than the dominant pulsation. With this, an entirely new research field has opened for these classical pulsators that focuses on the search and characterisation of the low-amplitude signals. Massive detection is achievable only with high quality photometric surveys, such as the OGLE, Kepler/K2 and TESS missions. While we still lack theoretical explanation for the majority of these periodicities, there is growing evidence that the so-called 0.61 group might be a gamechanger. This is the only group forming multiple clear sequences in the Petersen diagram, located at period ratios between 0.6 and 0.65 with the overtone pulsation, and has the best chance to have proper mode identification in the future. In this talk I will review the different types of additional signals in RR Lyrae and classical Cepheids also mentioning their connection to the mysterious Blazhko effect. I will discuss the latest developments of deriving metallicity and mass, and present the modeling efforts and the first steps that have been made recently to perform real asteroseismology of RR Lyrae and classical Cepheids.

[Contributed] CT17.1

Title: AGB Asteroseismology: Evolved Variable Stars as Laboratories for Stellar Evolution in Real Time

Author: Meridith Joyce
Affiliation: CSFK Konkoly Observatory

Co-authors: László Molnár
Co-authors affiliation: CSFK Konkoly Observatory

Abstract: Most of stellar evolution proceeds far too slowly to be observed on human timescales, but thermally pulsing asymptotic giant branch (TP-AGB) stars can provide an unusual exception. Thermal pulses are violent, rapid helium shell flashes experienced by sun-like stars at the end of their lives, during which the star's brightness can change by more than an order of magnitude in only ~100 years. However, given the short duration of the pulses compared to the several-thousand-year gaps between them, it is rare to catch a star in this phase of its life. The TP-AGB stars T Ursae Minoris and R Hydrae are confirmed to be in the midst of thermal pulses using asteroseismology, a deduction enabled by observing two dynamical behaviors simultaneously: thermal pulses, on the timescale of hundreds of years, and acoustic p-mode pulsations, on the timescale of hundreds of days. Our results hinge crucially on (1) multi-source, longitudinal observational data spanning centuries and (2) large grids of evolutionary and asteroseismic calculations. In this talk, I will discuss the application of the "seismic stellar evolution" modeling approach to study late-stage, classically variable stars, thus showcasing the state-of-the-art in asteroseismology of large-amplitude pulsators like AGB stars. Continued observations with TESS and Gaia offer a necessary supplement to the longer-timescale but lower-precision observations on which the characterization of oscillating AGB stars relies.

[Contributed] CT17.2

Title: Census of Non-evolutionary effects on period change from O-C study of 7000+ Magellanic Cepheids

Author: Rajeev Singh Rathour
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Abstract: Studies of period changes offer an avenue to probe the dynamics and evolution of Cepheids. While long-term evolutionary changes have been extensively studied, short-term non-evolutionary period changes (~100-1000 days) remain relatively unexplored. Utilizing O-C diagrams for around 7200 single-mode Magellanic Cloud (MC) Cepheids (both fundamental and first overtone) from the decade-long Optical Gravitational Lensing Experiment (OGLE) photometry, we conducted a systematic search for non-evolutionary period changes. In the first part of our study, we examined non-evolutionary effects resulting from the light-travel time effect (LTTE), indicative of binary systems. We identified 197 binary Cepheid candidates, constituting the largest known sample of such systems. We report their orbital parameters and the minimum masses of the companions. Our findings align with population synthesis predictions of binary Cepheids, particularly regarding the incidence rate ratio between the SMC and LMC. The second focus of our research was on irregular period changes of unknown physical origins. We compiled a refined inventory of ~1600 Cepheids from both MCs. We characterize these irregular period changes, including their incidence rates and associations with changes in phase and amplitude, across different pulsation modes and metallicity environments. Our work is an attempt towards disentangling such effects from those expected due to the secular evolution of these stars.

[Invited] IT17.2

Title: Closing talk

Author: Sarbani Basu
Affiliation: Yale University

(Physical) Posters[3]

[3] Abstract, author, and affiliation information is displayed as provided by the authors (i.e., unedited).

P1

Title: Do High-Amplitude Gamma Doradus pulsators constitute a separate subclass?

Author: Ádám Sódor
Affiliation: Konkoly Observatory, Hungary

Co-authors: Emese Plachy, Zsófia Bognár
Co-authors affiliation: Konkoly Observatory, HUN-REN CSFK, Hungary

Abstract: Probably yes – in a sense. The overall pulsation amplitude of gamma Doradus (GDOR) stars is not very actively studied. Paunzen et al. (2020, MNRAS, 499, 3976) identified 15 high-amplitude GDOR (HAGDOR) stars, defining them as their peak-to-peak light variation in Johnson V band exceeding 0.1 mag. Based on this set and on a similarly small control sample, Paunzen et al. concluded that HAGDOR pulsators are not physically distinct in any way from regular GDOR stars, except that they are situated at the high end of the continuous GDOR amplitude distribution. To extend this search, we investigated the original 4-year-long Kepler data exhaustively, and identified more than 3200 GDOR stars. Among these, about 80 are high-amplitude ones. We found that these HAGDORs all belong to one specific subclass of GDOR stars, which was defined by Balona et al. (2011, MNRAS, 415, 3531) as ASYM. Furthermore, most of these stars exhibit frequency groups in their Fourier amplitude spectra (studied in detail by Kurtz et al., 2015, MNRAS, 450, 3015). Even though GDOR stars in this particular subgroup can also pulsate with arbitrarily low amplitudes, other kind of GDOR stars never have high overall amplitudes anywhere near to the HAGDOR regime. We also found that the above described subclass of GDOR stars that HAGDORs belong to, seldom show simultaneous delta Scuti (DSCT) pulsations, that is, HAGDORS are significantly less likely to be DSCT-GDOR hybrid pulsators than their regular GDOR counterparts.

P2

Title: Validation of the RR Lyrae variables in the Pan-STARRS PS1 3π survey with K2

Author: Adrienn Forró
Affiliation: Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences

Co-authors: László Molnár (1); Emese Plachy (1); Róbert Szabó (1)
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Abstract: RR Lyrae variables are old, core-helium-burning stars on the Horizontal Branch that are important tools for tracing the structure of the Galaxy thanks to their high luminosity and their period-luminosity relation. Pan-STARRS observed a large number of them during its PS1 3π survey. However, as a ground-based telescope, it could only observe during nighttime and its 4-year-long light curves contain a dozen or so data points in each filter. Sesar et al. (2017) constructed a catalog of RR Lyrae stars found in the Pan-STARRS data. The objective of this study was to validate both the classification and the period determination of the stars. During Kepler's K2 mission only limited sky areas were observed, with a high sampling frequency, although each for a shorter duration of ~ 80 days. We investigated the overlap and found 1353 RR Lyrae stars in total. This list was also crossmatched with the Gaia DR3 and Gaia RR Lyrae catalogs. For the vast majority of the stars, the classification and the period from the K2 data was consistent with the Sesar et al.(2017) catalog and the Gaia data. Analyzing the frequencies of the remaning stars, we found a systematic difference, a 1 or 2 cycle/day offset between the datasets. It affected 7.4% of the sample, and 25.3% of RRc stars specifically. The reason of aliases in the Pan-STARRS frequencies is the sampling bias resulting from the diurnal cycle. Since the RRc subtypes have a less sharp light curve shape, they are more likely to be affected.

P3

Title: Improving Stellar Age Estimations and Exploring the [C/N] - Mass Relation with Normalizing Flows

Author: Alexander Stone-Martinez
Affiliation: New Mexico State University

Co-authors: Jon Holtzman
Co-authors affiliation: New Mexico State University

Abstract: Understanding the ages of stars is crucial for unraveling the history and evolution of our galaxy. Current methods for estimating stellar ages from the spectra often struggle with providing precise uncertainties and are limited by the parameter space covered by the training data. This work introduces a novel approach using normalizing flows, a type of deep generative model, to estimate stellar ages with a focus on improving the accuracy and descriptive power of uncertainties. Unlike standard convolutional neural network techniques, normalizing flows enable the recovery of likelihood distributions for the ages of individual stars, offering a richer and more informative perspective on uncertainty. This method not only yields age estimations for a wide array of stars but also intrinsically accounts for the coverage and density of the training data, ensuring that the resulting uncertainties are reflective of both the inherent noise in the data and its representativeness. To expand the training parameter space, we have incorporated age determinations from cluster stars and are exploring the use of mixing models for stars in the upper giant branch. Using this method with the upcoming milky way mapper data release we hope to have the most comprehensive stellar age catalog for galactic archaeology produced. The normalizing flow method also lends itself to detecting stars with abnormal abundances by using the same model with asteroseismic masses as part of the input space.

P4

Title: Pulsating stars with substellar companions

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Abstract: There is a small number of known pulsating stars with transiting exoplanets. The analysis of such systems is challenging because the pulsation distorts the transits and therefore, the proper subtraction of the pulsation pattern is essential in order to model the transit light curves correctly. In addition, in close systems, the tidal forces of the companion may influence the oscillations. We performed photometric analysis of such systems using TESS space telescope data. We modeled the transit light curves and determined the basic parameters of the systems. We also found evidence of tidally perturbed stellar oscillations related to the substellar companions.

P5

Title: Ambiguous Case of the V1216 Sco eclipsing binary

Author: Amadeusz Miszuda
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Co-authors: C. Eze (1), F. Kahraman Alicavus (2), C. Johnston (3,4), G. Handler (1)
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Abstract: V1216 Scorpii is a newly discovered SB2 eclipsing binary containing a Beta Cephei pulsator (Eze & Handler, 2024). A first inspection of the light curve suggests a borderline between detached or semi-detached geometry and shows the O'Connell effect, high amplitude pulsations, and a considerable asymmetry of the flux at ingress and egress of the primary eclipse. All these pose challenges to modelling the light curve of this system. Our analysis suggests that V1216 Sco is a post-mass transfer binary, with 9.8 Ms and 3.7 Ms main sequence stars. In our poster, we show the current state of analysis of the system with the frequency search and the binary evolutionary modelling.

P6

Title: HAYDN - High-precision AsteroseismologY of DeNse fields

Author: Andrea Miglio
Affiliation: Università di Bologna

Co-authors: HAYDN science consortium

Abstract: Astrophysics is now entering an era of unprecedented large-scale, multi-messenger surveys: Gaia, JWST, Roman, Euclid, Rubin/LSST, PLATO and LISA from space, and large complementary efforts from the ground (e.g. ELT, large spectroscopic surveys), are giving us the potential for a step change in our understanding of properties and processes of the physical Universe. The interpretation of this wealth of data relies, however, on our understanding of the building blocks of cosmic structures: stars and star clusters. In this poster we discuss the scientific rationale and current concept of the HAYDN ESA M-class mission candidate, a space mission specifically dedicated to gathering long photometric series of large samples of coeval and initially-chemically-homogeneous stars in open and globular clusters. Such a mission would transform stars into laboratories, enabling us to test stellar physics and catalysing the development of next-generation stellar models, thus reinforcing the foundations of astrophysical inference.

P7

Title: Stellar characterization using Machine Learning

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Abstract: Stellar characterization is critical for many astrophysical fields. Among all the stellar characteristics, stellar masses, radii, and ages are the most difficult variables to estimate. In our toolkit, we have a few golden techniques for this task, such as Eclipsing Binaries, Asteroseismology, and Cluster pertinence, to name some. Unfortunately, they can be applied only to a small number of stars. For the rest, other less accurate techniques are used such as model fitting or data-driven relations. In addition, we all demand rigorous handling of uncertainties to ensure the credibility of outcomes. In the field of data-driven inferences, the growing integration of artificial intelligence (AI) and machine learning (ML) offers a novel avenue to address these necessities. This convergence presents an opportunity to create advanced models capable of quantifying diverse sources of uncertainty and automating complex data relationship exploration, among other things. In this talk, we introduce a complete machine-learning architecture for estimating stellar masses, radii, and ages. We propose the combination, using Stacking, of a new Hierarchical Bayesian Neural Network (HBNN), a Bayesian Random Forest, a Gaussian Process, and a Gaussian Regression. As a training data set, we use stars with accurate masses, radii, and ages coming from different golden techniques, with asteroseismology as the main contributor. We also present some applications of these models to exoplanetary host stars.

P8

Title: PULSEY: Python Package for Modeling Stellar Pulsation

Author: Andrew Ayala
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Abstract: PULSEY is a python program built on top of an existing package titled STARRY; a python tool which constructs 3-D spherical surface maps via an amalgamation of individual spherical harmonic modes. The summation of these individual modes produces a static 3-D map that can be inclined, rotated, and inserted into a binary system. Now with PULSEY, one can create periodic pulsation or time evolution of these 3-D surface maps by sinusoidally varying the amplitude of orthogonal spherical harmonic modes. With this new functionality, we can model observed stellar pulsation or photometric variability by periodically modulating spherical harmonic coefficients. Alongside this, the binary system functionality of the package allows for eclipse mapping of pulsation modes to break symmetries and degeneracies witnessed in observational data. There is also the potential to model asymmetric phenomena such as tidally tilted pulsations. As well, importing other packages such as GYRE and MSG can allow for the spectral modeling and analysis of resultant pulsation modes. Ultimately, PULSEY enables us to model eclipses of pulsating stars to identify the L and M values of the spherical harmonic patterns associated with individual pulsation modes observed in data.

P9

Title: Magnetic activity and its variability in the Sun and Solar-like stars

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Abstract: The light curves of solar-like stars provide information on stellar rotation and magnetic activity thanks to active-region crossings. In this work, we investigate the temporal variation of the photometric magnetic activity of the Sun and Kepler solar-like stars. We find that the most active stars are those exhibiting the most significant variations, independently of the spectral type. This relationship was known for chromospheric activity, but here we show that photometric data have a similar behavior. Because of the bimodal rotation-period distribution, there are two regimes in the activity-rotation relation: slow- and fast-rotating branches. While stars in the fast-rotating branch tend to have higher activity levels (in general) than the slow-rotating branch, their temporal variation is consistent, with both branches following the same relationship. We also compare the Sun with Sun-like stars, a subsample with very similar properties to the Sun selected according to their effective temperature, surface gravity, and rotation. While the Sun is among the less active stars (depending on the cycle's phase), we find that the behavior of the Sun's magnetic activity is consistent with that of Kepler Sun-like stars. Finally, we also find evidence for the metallicity impact on the rotation evolution. This kind of analysis helps improve our understanding of solar/stellar magnetism and its associated timescales. Future PLATO will bring a new opportunity in this direction.

P10

Title: Possible Binary Origin of Be stars

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Abstract: Astronomers have long been puzzled by the rapid rotation of Be stars, leading to various theories for its origin that can be grouped into a single-star hypothesis and a binary interaction scenario. Recent studies suggest single stellar evolution could be viable if Be stars start their main-sequence phase with core rotation rates ≥ 60% of critical velocity, but fail to explain their observed surface nitrogen enhancement. Conversely, if binary interactions drive rapid rotation, some Be stars should appear single due to disruption of the binary during the companion undergoing supernova, with their current velocity distribution reflecting the pre-supernova orbital parameters. Our analysis of high-resolution Hermes spectra of single Be stars in the Galactic disk reveals a distinctive double-peak velocity distribution. Using a novel combination of spectroscopic analysis with rapid binary population synthesis, we find that the low-velocity peak at 30 km/s can be well explained by Be stars originating from a binary population. However, the observed high-velocity peak at 80 km/s remains unexplained by a purely binary population, suggesting dynamic ejections from a cluster. Our findings suggest that binary interactions can account for nearly 80% of all Be stars. Finally, we describe how we apply asteroseismology using Tess photometry to probe the core rotation and internal mixing, allowing us to yield more precise constraints on the relative importance of single and binary channels.

P11

Title: Towards Precise Stellar Parameters: Asteroseismology of Red Giants in Eclipsing Binaries

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Abstract: The asteroseismic scaling relations have enabled the determination of stellar masses and radii for many solar-like oscillators on the main sequence. However, because the scaling relations are calibrated with solar values, applying them to more evolved stars results is known to be less accurate. There is a need to re-calibrate the scaling relations for evolved solar-like oscillators. To do so, we may look to eclipsing binary systems (EBs) containing a red giant solar-like oscillator component. Masses and radii of such systems can be precisely measured using EB analysis, and subsequently compared with the mass and radius found via scaling relations. We have developed a pipeline to search TESS 2-min cadence photometry of EBs with -evolvedsolar-like oscillating components. The pipeline detrends and prepares the TESS data so that outliers, long-term trends, eclipses, and instrumental variations are removed.With the adjusted light curve, we produce a power density spectrum, which we assess (by eye) for solar-like oscillations. During our preliminary search, we have applied this pipeline to an initial sample of 178 EBs with characteristics suggesting an evolved component, as listed in the Villanova TESS EB Catalog. We are currently gathering radial velocity measurements for two newly identified targets, which we will model using PHOEBE (PHysics Of Eclipsing BinariEs).We plan to extend our search to include the TESS Full Frame Images and Gaia EBs. Our pipeline will be made publicly available for community use.

P12

Title: Modelling of dipolar magnetic reversals for low mass stars

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Abstract: Recent spectropolarimetric observations of low-mass stars show that large-scale components of their magnetic fields can exhibit cyclic variations or reversals. This magnetic activity affects detection of exoplanets and estimation of their masses, and so its modelling is particularly important. In convective stellar envelopes, magnetic fields are created through dynamo action - systematic stretching and twisting of magnetic field lines by helical convective vortices. It is yet however unclear how low-mass stars, with their strong convective turbulence and relatively slow rotation, are able to maintain coherent large-scale magnetic activity. In this work, we elucidate physical mechanisms that allow magnetic flux to accumulate at large scales in both turbulent and strongly stratified models of stellar convection. In such models, a highly turbulent convective layer is formed at the surface while the deep flow interiors remain rotationally constrained. Our results show that small-scale magnetic flux, generated by small-scale turbulence in the outer regions with low density, is systematically transported into more quiescent inner regions by global magnetic pumping mechanism. Consequently, the dipolarity of the field at the surface of the domain increases both with enhancement of turbulence and stratification. These dipolar large-scale fields are unstable and exhibit reversals which can be responsible for magnetic variations observed in low-mass stars.

P13

Title: A grid of delta Scuti models and modelling systematic uncertainty analysis

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Abstract: Asteroseismology of delta Scuti stars depends critically on successful mode identification and comparison of observed frequencies with accurate stellar models. To address the latter, we present a comprehensive grid of 35 million stellar pulsation models, computed using the MESA and GYRE codes. These models range from the pre-main sequence to the terminal-age main sequence and span a wide range of initial masses, metallicities, and rotation rates. Compared to Murphy et al. (2023)[https://arxiv.org/abs/2306.13142], we have added rotation, expanded the age range of the calculations, and we now include g- and mixed modes (and their avoided crossings). Existing modelling approaches lack a thorough characterisation of their inherent systematic uncertainties. Addressing this gap, we examined the effects of key physical parameters, such as convective overshoot, mixing length alpha, and nuclear reaction networks, on the stellar pulsation frequencies. By systematically varying these parameters across the grid, we quantify these uncertainties across diverse evolutionary tracks. Our grid and the accompanying systematic uncertainty study will serve as a community resource, allowing for more accurate and reliable asteroseismic inferences of delta Scuti stars. In the future, our first intended application is to model rotationally split modes of delta Scuti stars in the Pleiades cluster, which should refine the ages, rotation rates, and even inclinations for these stars.

P14

Title: Ground and Space based Investigation of Intermediate age Open Star Cluster NGC 2126

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Abstract: We performed the ground based time-series observations of intermediate age open cluster NGC 2126 with 1.3 m Devasthal Fast Optical Telescope (ARIES), and discovered 112 variable stars in the field. Among these 11 stars were known variables, for them we performed TESS Full Frame Image photometry in three different sectors. The membership of the identified variables were determined using machine learning technique HDBSCAN using Gaia DR3 proper motion and parallax. There were 17 new member variables and 84 field stars. The basic parameters of the cluster were determined using isochrone fitting on gaia color-magnitude diagram. An eclipsing binary, V551 Aur is a member of NGC 2126 with high probability, it was thought to be a pulsating eclipsing binary, however our analysis argues that it is more likely to be a triple system. This star was studied in detail with low and medium resolution spectra and TESS photometry. The eclipse was modeled and removed to treat the eclipse and intrinsic variability separately. The new variable members were classified based on their position in the HR diagram, shape of the phase folded light curves, period and amplitude of variability. We modeled and derived the basic parameters for two more eclipsing binaries, where one of them is a field binary and other a member binary which was not modeled previously due to lack of data. We modeled this binary using the TESS data to derive basic parameters based on the light curve alone.

P15

Title: Twinkle twinkle undersampled star: Asteroseismic insights into Kepler late subgiants, and early red

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Abstract: During the late subgiant/early giant stage, stars undergo fast evolutionary changes such as the readjustment of their internal rotation. It is paramount to study this phase in particular to understand the transport of angular momentum from the core of stars to their envelope. Bridging this knowledge gap is crucial to obtain more precise stellar age determination. Asteroseismology is a potent tool to analyse the internal structure and dynamics of stars. However the sample of seismically characterised late subgiant/early RGBs is very small with Kepler data mainly because of instrumentation limitations: the modes of these stars happen to be located beyond the Nyquist frequency. We investigate the ways to detect undersampled stars in the Kepler dataset and measure their seismic modes and global parameters with an extension to the new python Py-A2Z pipeline. Our methodology relies on the asymptotic repeating structure of the oscillation spectra of solar-like stars to detect and characterise oscillations. We also extensively use seismic scaling relations to discriminate between undersampled and correctly sampled lightcurves. In this poster, I will showcase the efficiency of the methodology'. This enabled the measurement of global seismic parameters of over 350 stars whose modes were close or beyond the Nyquist frequency expanding the known sample of super-Nyquist oscillators by a factor of 4. Finally, I will also briefly discuss the prospects these results open up for the advance

P16

Title: Constraining stellar cores in the main sequence mass-transition zone

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Abstract: Proper modeling of the interface between convective and radiative interiors is one of the most challenging open questions in modern stellar physics. The treatment and implementation of stellar model physics (such as core convective overshoot) in models with small cores has significant impact on the nature and size of stellar cores of stars. Main-sequence stars in the mass transition region where their cores may become convective offer an excellent opportunity of testing our understanding of stellar model physics. In this poster, we showcase our findings which entail a detail analysis of an ensemble of binary stars in the mass transition region, with known orbital and stellar parameters (such as dynamical mass and radius). These parameters offer additional constraints on our optimisation routines, allowing to isolate the effects of core convective overshoot and atomic diffusion on the nature of stellar cores.

P17

Title: New trees in the mixed-mode forest

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Abstract: A large interest of red giant seismology comes from the ability of dipole modes, which behave has mixed modes, to probe the stellar core of the evolved stars. Unique information has been derived from the mixed-mode pattern, such as evolutionary stage, core rotation, mass transfer, buoyancy glitches…The careful analysis of individual oscillation spectra shows that extra peaks are sometimes present in core-helium burning stars, which do not follow the asymptotic expansion derived from the coupling of a gravity cavity and a pressure cavity. We used the formalism developed to account for complicated cases, as the presence of strong structure glitches or multiple cavities (Cunha et al. 2015, Deheuvels & Belkacem 2018, Pinçon & Takata 2022), to decipher the extra peaks. We could interpret them in terms or supernumerary mixed modes. The determination of the extra asymptotic terms associated with the additional modes makes it possible to better describe the core structure of these stars.

P18

Title: Magnetic Coriolis darkening in cool stars

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Abstract: Modeling the surface brightness distribution of stars is of prime importance to interpret the large amount of available interferometric, spectropolarimetric, or photometric observations. Beyond stellar physics, this is also a prerequisite to characterize exoplanets or our Galaxy. Nevertheless, this remains quite challenging for cool stars as it requires one to model the magnetohydrodynamic turbulence that develops in their convective envelope. In this work, the effect of the Coriolis acceleration and dynamo magnetic fields on the surface convective flux has been studied by means of 3D spherical simulations of thick convective envelopes. We focus on an envelope thickness that is representative of either a 0.35 Msun dwarf, a young red giant star or a pre-main sequence star. This poster presents the results of the parametric study. We explain the three different regimes observed depending on the assumed convective efficiency and discuss the repercussions of these findings in the context of the exoplanet detection by the transit method.

P19

Title: The characterization of solar-like asteroseismic modes for the PLATO pipeline using deep learning

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Abstract: The launch of the PLATO mission in 2026 will grow the current asteroseismic catalogue of main sequence stars hundredfold. Machine learning (ML) methods present the opportunity to determine common asteroseismic parameters accurately and in a fraction of the time of previous methods. Here, we propose a pipeline of machine learning models that can categorise stars (main sequence, evolved, or noise), obtain the key parameters $\delta\nu$ and $\nu_{\rm max}$, and then determine asteroseismic parameters such as epsilon, enabling the mode identification of main sequence stars. We build a dataset of synthetics that encompass all of the major parameters for solar-like pulsators (inclination, signal-to-noise, rotation, $\nu_{\rm max}$, etc.) and govern the structure of stellar power spectra. A one-dimensional convolutional neural network (CNN) then classifies the stars into main sequence, sub-giant, or non-oscillators. If the star is a main sequence star, the pipeline then determines $\nu_{\rm max}$ and $\Delta\nu$, which are key parameters for mass and radius calculations. Finally, we utilise two-dimensional CNNs to determine asteroseismic parameters such as ϵ. Using the current Kepler catalogue, we compare the parameters obtained from the ML pipeline to those available in the literature.

P20

Title: Understanding the Mechanisms Behind Convective Boundary Mixing Through Asteroseismic Modelling

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Abstract: Stars with masses above about 1.2 solar masses will host convective cores, but the stellar structure at and around the convective boundary is currently underconstrained. Physical processes such as convective penetration are thought to extend the limits of well-mixed convective zones past classical convective core boundaries, altering stellar structure and leading to extended main sequence lifetimes. In addition to convective penetration, other interior processes as stellar rotation, interior oscillations, and hydrodynamic instabilities — may also change the interior mixing properties of stars. 1D prescriptions for convective penetration have recently been calibrated on 3D hydrodynamical simulations of stellar convective boundaries, and implemented in stellar evolution codes. Building on this work, we calculate grids of stellar models incorporating these prescriptions as well as extra mixing beyond convective penetration. We find that the 3D-motivated convective penetration above main sequence convective cores alters the gravity-mode cavity properties during the subgiant phase of evolution, affecting the mixed-mode frequencies of the stellar models. Using data from Kepler and TESS, we then compare the models' oscillation mode frequencies to observed frequencies in order to determine how much extra mixing beyond convective penetration is needed to match the asteroseismic data for a set of evolved stars. We also discuss possible physical interpretations of these findings.

P21

Title: Acoustic modes in M67 cluster stars trace deepening convective envelopes

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Abstract: Acoustic oscillations in stars are sensitive to stellar interiors. Frequency differences between overtone modes –large separations– probe stellar density, while differences between low-degree modes –small separations– probe the sound speed gradient in the energy-generating core of main sequence Sun-like stars. At later phases of stellar evolution, characterised by inert cores, the small separations are believed to become proportional to the large separations. Here, we present clear evidence of a rapidly evolving convective zone as stars evolve from the subgiant phase into red giants. By measuring acoustic oscillations in 27 stars from the open cluster M67, we observe deviations of proportionality between small and large separations caused by the influence of the bottom of the convective envelope. These deviations become apparent as the convective envelope penetrates deep into the star during subgiant and red giant evolution, eventually entering an ultra-deep regime that leads to the red giant branch luminosity bump. The tight sequence of the cluster stars, free of large spreads in ages and fundamental properties, is essential for revealing the connection between observables –small separations– and the chemical discontinuities occurring in deep stellar interiors. We use this sequence to show that combining large and small separations can improve estimations of mass and age well after the main sequence.

P22

Title: Are Hydrogen-deficient Carbon Stars Pulsating?

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Abstract: Hydrogen-deficient Carbon (HdC) stars, which includes the dusty R Coronae Borealis (RCB) variables and their dustless counterparts (dLHdC), exhibit variations in brightness at maximum light, with V band semi-amplitudes up to 0.5 mag. Previous studies have not conclusively determined if these variations represent coherent pulsations or stochastic low-frequency fluctuations. This poster presents preliminary findings from analyzing HdC light curves from over 8 optical time domain surveys and historical AAVSO data. One RCB star (RY Sgr) shows evidence of both stochastic low-frequency noise and a highly damped p-mode oscillation with P=38.6 days, similar to other red supergiant pulsators. More detailed analysis is needed to detect oscillations in other stars. Future work will employ Gaussian Processing to detect weak modes hidden within the noise and strong spectral window.

P23

Title: Asteroseismology meets open clusters

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Abstract: Open cluster, as stellar ensembles, allow us to probe stars of common age and composition across a range of masses. With the Gaia and TESS missions, we are now in a position to combine asteroseismology and open cluster studies to advance both fields. Gaia provides accurate open cluster memberships including stars at large distances from the cluster center while TESS delivers nearly full-sky time series photometry for these stars. TESS's mission duration, spanning now over five years, renders all observed open clusters viable targets for g-mode asteroseismology. The long time-baseline allows us to observe and identify period spacing patterns in g-mode pulsators, enabling thorough asteroseismic exploration and modelling. Due to their properties as homogeneous stellar populations open clusters serve as independent calibrators for asteroseismology in particular for age dating, but also to probe internal mixing and angular momentum transport across stellar evolution. The unique combination of coeval stars of different masses in open cluster allows to combine previously independent methods with g-mode asteroseismology. We illustrate the synergies between open cluster studies and asteroseismology, focusing on various case studies of open clusters observed with TESS. Further, we highlight how our advanced understanding of open clusters from Gaia can help asteroseismic explorations.

P24

Title: ÆSOPUS 2.1: low-temperature gas opacities library and its application in asteroseismology

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Abstract: We present ÆSOPUS 2.1, a publicly-available tool designed to compute low-temperature gas opacities. The tool covers temperatures from 100 K to 30000 K (with next nearly-future expansion), and allows user-customized chemical composition, counting 92 elements in addition to the most used solar mixtures from literature (including Magg et. al 2022). The code is originally designed for computing Rosseland mean opacity tables taking into account over 800 atomic species including atoms, ions, molecules and solid grains,and is now updated with molecular absorption expanded to include 80 species. The table covers an interval of temperature and density particularly suitable for describing the outer parts and atmospheres of cool stars, including red giants and other solar-like oscillator. We will show the effect of our opacity calculations on the outer layers, which are essential for the proper modelling those stars. The impact of our tables on the surface layers will also affect asteroseismic calculations of the mode frequencies, enabling the derivation of more precise stellar properties.

P25

Title: The breakdown of current gyrochronology as evidenced by old coeval stars

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Abstract: Gyrochronology can yield useful ages for field main-sequence stars, a regime where other techniques are problematic. Typically, gyrochronology relations are calibrated using young (2 Gyr) clusters, but the constraints at older ages are scarce, making them potentially inaccurate and imprecise. In order to test the performance of existing relations, we construct samples of stellar pairs with coeval components, for a range of ages and with available rotation periods. These include randomly paired stars in clusters, and wide binaries in the Kepler field. We design indicators that, based on the expectations from gyrochronology, quantify the (dis)agreement between the coeval pairs and the gyrochronology calibrations under scrutiny. Our results show that wide binaries and cluster members are in better concordance with gyrochronology than samples of randomly paired field stars, confirming that the relations have predicting power. However, the agreement with the examined relations decreases for older stars, revealing a degradation of the examined relations with age, in agreement with recent works. This highlights the need for novel empirical constraints at older ages that may allow revised calibrations. Our test is independent of any specific age–rotation relation, and it can be used to evaluate future spin-down models. In addition, taking gyrochronology at face value, our results provide new empirical evidence that the components of field wide binaries are indeed coeval.

P26

Title: Kepler meets Gaia: Binary Systems, Color-Magnitude Diagram, and Kinematic Analysis

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Abstract: The Kepler mission has delivered unprecedented high-quality photometry. These data have impacted numerous research fields including Galactic studies, asteroseismology, and exoplanets, and continue to be an astrophysical goldmine to this day. Because of this, thorough investigations of the ~ 200,000 stars observed by Kepler remain of paramount importance. In this talk, I will present three aspects of a state-of-the-art characterization of the Kepler targets based on Gaia DR3. First, we report several categories of candidate binary systems spanning a range of detection methods, such as Renormalised Unit Weight Error (RUWE), radial velocity variables, Gaia non-single stars (NSS), and eclipsing binaries. Second, we investigate the color-magnitude diagram (CMD), and classify stars into several CMD categories (dwarfs, subgiants, red giants, among others). Third, we use the Gaia DR3 astrometry to perform a detailed kinematic analysis. We classify the Kepler-field stars among different Galactic components (thin disk, thick disk, halo), and approximately triple the sample size of previous works. We explore the role of their Galactic population membership in properties such as stellar rotation, asteroseismic ages, and chemical composition. Our multi-dimensional analysis will constitute a valuable resource for future research on the Kepler stars and their planets, and highlights the capabilities of combining the Gaia data with photometric missions such as TESS and the upcoming PLATO.

P27

Title: Measuring Surface Rotation of Stars in Open Clusters by Combining Multi-Sector Data from TESS FFI

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Abstract: Measuring the rotation period of stars in open clusters provides an excellent opportunity for the calibration of gyrochronology relationships since stars in clusters have the same age and chemical composition. It has already been shown that TESS Full Frame Images can be used to extract rotation periods. TESS has already conducted two complete all-sky surveys. Combining these multi-sector data allows us to probe rotation periods beyond the typical limit of around 13 days, half of TESS's 27-day sector observation period. Measuring the rotation period from combined multi-sector data is challenging due to inter-sector gaps (~13 days), sector gaps (over years), and phase shifts in the light curve while combining long-gapped data. These challenges were addressed by using FFI light curves processed using the PYTADACS package. The rotation periods were estimated using the STAR_PRIVATEER package. The large pixel size of TESS (21'') also leads to source contamination, which is particularly important in clusters due to the high spatial density of stars. In this poster, we present a preliminary analysis of clusters with ages from 0.5 to 2.5 Ga, showcasing different methods developed to tackle all the above mentioned problems.

P28

Title: Asteroseismic probes of dark matter

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Abstract: One of the greatest challenges in modern astronomy is the problem of dark matter: in particular, most of the matter in the universe appears to be invisible. Asteroseismology is one of the most precise fields of astronomy and is therefore useful in trying to further our understanding of the properties of dark matter. In this work, we will present models of stars that have accumulated dark matter in their interior, and show how this affects their pulsation properties.

P29

Title: A “complex network” perspective on δ Sct stars

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Abstract: To have a more comprehensive study of pulsating stars as nonlinear systems accompanied by Asteroseismology, we applied the “complex network” approach by considering the δ Sct stars as “complex systems”. Complex systems are composed of a large number of highly interconnected dynamical units that exhibit emergent collective properties. By using the horizontal visibility algorithms, the light curves observed by TESS are mapped to Horizontal Visibility Graphs (HVGs), where the nodes represent the light curve’s points. The connections between nodes happen when points are able to see each other along the horizontal lines of sight. δ Sct stars with spectral types A0-F5 and intermediate masses pulsate in low-order pressure modes and have dominant frequencies in the 5-80 d^{-1} range. By considering the degree distributions of stellar networks, both lognormal and power-law behaviors are likely not to be rejected, and deviation from the analytical uncorrelated random series is evidence for non-random processes. The average shortest path length of the HVG network of δ Sct light curves is a linear function of the network sizes (logarithm), indicating the small-world and non-random properties. Also, HADS stars show higher transitivity indicating simpler light curves. Calculating the Kolmogorov–Smirnov distance of the HVG nodes’ degree distribution of a δ Sct light curve with an analytical expression of an uncorrelated random time series may be a helpful tool for frequency cleaning.

P30

Title: Gravity-Mode Period Spacings of the Hybrid \gamma Doradus / \delta Scuti Star HD49434

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Abstract: The gravity (g-) mode pulsations of \gamma Doradus stars are ideal probes of the convective core boundary, and their non-equidistant spacings, a robust measure of near-core rotation and chemical mixing. For hybrid stars which also pulsate in pressure modes, this can be extended to the outer envelope, enabling differential studies and unparalleled constraints on stellar structure. Our work aimed to identify the pulsation frequencies of a candidate hybrid \gamma Doradus \delta Scuti star and use these to inform its g-mode period spacings. We used iterative prewhitening to extract the pulsation frequencies and then group these according to spectroscopic geometric description, forming the basis of the search for period spacings in the datasets. Our results suggest HD 49434 exhibits 12 successive quadrupole (l=2) sectoral (l=m) g-modes and 6 successive dipole (l=1) sectoral g-modes in the form of two distinct patterns of decreasing period spacing. Additionally, the large local dips in the quadrupole series suggest mode trapping in layers of chemical inhomogeneity. The detection of independent modes in the \gamma Doradus and \delta Scuti regimes is confirmation that HD 49434 pulsates in both pressure modes and g-modes. The patterns presented in this analysis provide a strong foundation for the future asteroseismic analysis of HD 49434, enabling a better understanding of stars in the hybrid regime.

P31

Title: Influence of the magnetic cycle on the excitation of solar-like acoustic modes

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Abstract: The Sun's convective envelope generates, by dynamo effect, a surface magnetic field whose strength evolves on an 11-year cycle, with a change in polarity at the end of each cycle. Similar activity cycles exist in other solar-type stars, influencing the star's dynamics, including the properties of acoustic oscillations, which are excited by convection. Thus, the frequency, amplitude, excitation, and damping of the modes vary with the cycle over time and we need to understand it in order to characterise stars that will be observed by PLATO. In this work, we investigate the variation of modes excitation during Cycles 23, 24 and the beginning of Cycle 25 for the Sun. To do so, we analyse data obtained since 1996 by two instruments on the SoHO satellite: the GOLF spectrometer and the VIRGO/SPM photometer according to a method gathering a better resolution than classical methods. Combining the variations of energy for several modes $l = [0 - 2]$ in three frequency bands (i.e. [1800, 2450], [2450, 3110], [3110, 3790] μHz), our preliminary results show that more energy is associated to several modes during cycle minima, suggesting that there could be a second source of excitation other than turbulent convection that would excite several modes at a time during solar minima. We then extend the analysis to other solar-like stars observed by Kepler. In particular to KIC 8006161 (aka Doris), a solar-like star whose cycle lasts 7.41 ± 1.16 years, observed during one of its cycle minimum.

P32

Title: Hidden magnetic fields in stellar interiors probed by asteroseismology.

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Abstract: Understanding the distribution and evolution of angular momentum is crucial for comprehending star formation processes, stellar evolution and activity, and its influence on planet formation and environment. Recent space photometry missions such as CoRoT and Kepler have revolutionized our understanding of stellar structure and evolution by highlighting discrepancies in current angular momentum transport models. However, incorporating magnetic fields into these models could offer a solution to this transport problem. Even though detecting and measuring magnetic fields within stellar interiors utilizing perturbative methods through asteroseismology is a recent breakthrough, there remains a need for a non-perturbative model, of which the first steps of the development will be presented in this poster. This model would comprehensively consider both stellar rotation and magnetic field in a two-dimensional framework, testing the existing perturbative methods, surpassing their limitations and tackling the area of strong and complex internal magnetic fields.

P33

Title: A comprehensive catalogue of asteroseismic properties of red-giant stars

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Abstract: Kepler observed ~32,000 red-giant stars. Red giants exhibit non-radial oscillation modes that carry information about the entire stellar structure, from core to envelope. Hence, characterising these modes is of utmost importance as these provide the most direct way to probe the internal structure of stars. Here, for the first time, we present a homogeneous catalogue of these ~32,000 red giants with global asteroseismic parameters and their solar-like oscillation properties (i.e. frequencies, linewidths, amplitudes, and mode identification) extracted with TACO (Tools for the Automated Characterisation of Oscillations). In addition to contributing to our knowledge of stellar evolution theory, the extended asteroseismic data set will allow us to estimate stellar parameters - mass, radius, evolutionary stage, and age - relevant to other fields like exoplanets and Galactic archaeology.

P34

Title: Multitapering for astronomical time series: Precise frequency estimation and the harmonic F test

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Abstract: We introduce mtNUFFT, the multitaper power spectrum estimation method for analyzing time series data that are quasi-regularly spaced in time. We will first review the original multitaper method invented by Thomson (1982) at Bell labs that has been used in geophysics, seismology, helioseismology and signal processing. The multitaper technique for harmonic analysis is ubiquitous in engineering and many other fields, but has gone relatively unused in astronomy, perhaps because the original method is for data evenly sampled in time. We have developed mtNUFFT, which allows for quasi-regularly spaced time series analysis with multitaper through a Python package called tapify. One key advantage of the multitaper approach is that it provides a harmonic F-test to test the hypothesis that a signal in the power spectrum is from a strictly periodic signal. We will demonstrate some example applications of mtNUFFT and the F-test to asteroseismology and RR Lyrae stars, showing both its advantages and drawbacks. This overview poster will cover work being completed within the Astrostatistics Research Team (ART) at the University of Toronto, which is a joint research team between the David A. Dunlap Department of Astronomy & Astrophysics and the Department of Statistical Sciences at the University of Toronto.

P35

Title: Exploring the Properties of TESS Chemically Peculiar Stars

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Abstract: The study of chemically peculiar (CP) stars has the potential to revolutionise our current understanding of processes at play inside all stars. Specifically, pulsating CP stars are perfect laboratories for studying stellar physics, as asteroseismology provides robust observational constraints. As a first step towards comprehending the intricacies of these stars, in this work, we focus on a particular group of pulsating CP stars: the rapidly oscillating chemically peculiar A-type (roAp) stars. So far, conducting studies of roAp stars has been especially difficult due to the rarity of these objects. However, the large-scale TESS and Gaia surveys have truly expanded our horizons, allowing for the collection of data for ~100 roAp stars. We homogeneously determine seismic and non-seismic parameters of these stars and analyse them using a plethora of methods, to be showcased here. We find evidence for the existence of two different populations in the data when closely inspecting the radial order of these stars. Comparing the results with state-of-the-art theoretical stellar models, we conclude that one of these populations cannot be explained by the models. Going forward, this finding will contribute to further development of stellar models, and ultimately improve our understanding of the mechanisms that drive the pulsations in roAp stars.

P36

Title: Stellar flares in hiding: Detecting stellar flares in photometric data using hidden Markov models

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Abstract: In this talk we will introduce our hidden Markov model (HMM) for discovering stellar flares in light curve data of stars. HMMs provide a framework to model time series data that are non-stationary; they allow for systems to be in different states at different times and consider the probabilities that describe the switching dynamics between states. In the context of stellar flares discovery, we exploit the HMM framework by allowing the light curve of a star to be in one of three states at any given time step: Quiet, Firing, or Decaying. This three-state HMM formulation is designed to enable straightforward identification of stellar flares, their duration, and associated uncertainty. This is crucial for estimating the flare's energy, and is useful for studies of stellar flare energy distributions. We combine our HMM with a celerite model that accounts for quasi-periodic stellar oscillations. Through an injection recovery experiment, we demonstrate and evaluate the ability of our method to detect and characterize flares in stellar time series. We will visually demonstrate that simultaneously conducting detrending and flare detection can mitigate biased estimations arising in multi-stage modelling approaches, and more easily detect fainter and lower energy flares. Thus, this method paves a new way to calculating stellar flare energy. We will conclude with an example application to star data observed by TESS, showing how the HMM compares with sigma-clipping when using real data.

P37

Title: Subgiants and Lower Giants in the TESS Continuous Viewing Zones

Author: Jamie Tayar
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Abstract: The Continuous Viewing Zones of TESS represent regions with years of precise, space-based photometry. In these regions, we have targeted the stars on the subgiant branch and lower giant branch, regions that were understudied by the Kepler Mission. We show that the TESS data is sufficient to measure asteroseismic parameters for more than 80 stars. We also discuss how these stars can be used to study TESS detection systematics, the quality of stellar evolution models in this regime, the evolution of the galaxy with age, and the physics of internal angular momentum transport.

P38

Title: Dead Ringers: A Pulsation Explanation for Supersoft X-Ray Oscillations

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Abstract: X-ray monitoring over the past couple of decades has revealed that some novae exhibit variability, with periods ranging from tens of seconds to an hour, throughout the supersoft phase. While the supersoft X-ray oscillations (SSXOs) with periods greater than 5 minutes have been linked to the rotation of a magnetized white dwarf, the origin of short period (10s of seconds) SSXOs remains a mystery. Using MESA with wd_builder, we have constructed a model of a 1.3 solar mass CO white dwarf (matching mass and composition estimates of RS Oph, a recurrent nova with a twice-measured 35s SSXO period) going through outburst and the subsequent supersoft phase. Calculating the dipole (l=1) oscillation modes of the WD with GYRE, we find that envelope g-modes go through a series of avoided crossings with a core-trapped mode whose 35s period remains constant throughout the supersoft phase. Using a classical analog to the quantum-mechanical Landau-Zener effect, we determine that approximately 60% of the initial energy stays in the 35s mode as avoided crossings are traversed, with the remainder leaking into the envelope where it can stimulate the observed variability. This core mode is a promising explanation for the origin of SSXOs, provided the outburst can energize the mode.

P39

Title: Grid-based Modelling of Low-Metallicity Red Giants Utilising Individual Asteroseismic Frequencies

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Abstract: We present the modelling of the low-metallicity Kepler red giants KIC 4671239 (Hennes) and KIC 7693833 (Rogue), which have been persistently challenging to characterise in accordance with expectations. We employ the grid-based modelling approach, where the observed stellar parameters are fitted to a grid of stellar models using the BAyesian STellar Algorithm (BASTA). Applying this to singular stars entail creating highly specialised grids suitable for the individual star, enabling detailed modelling. Uniquely for the contemporary work, for the first time within a grid-based modelling framework, is the inclusion of fitting directly to the observed individual frequencies of red giants. We find that the increased level of detail in the specialised grids, combined with the constraints from the individual frequencies, results in both stars obtaining considerable ages that align with expectations.

P40

Title: Visualising Asteroseismolgy

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Abstract: We present a visualisation tool for asteroseismology, freely available online for outreach and teaching applications. The tool is capable of visualizing stellar oscillations in various ways - both theoretical and observational aspects - such as mode mixing, measuring techniques, power spectra and effects of rotation.

P41

Title: An ongoing asteroseismic search for red clump stars in binaries

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Abstract: Binaries composed of two oscillating stars, referred to as asteroseismic binaries, offer a unique and previously untapped opportunity of improving our models of stellar evolution and binary populations. In this contribution, we will present our ongoing efforts to search for asteroseismic binaries using a combination of classical (Gaia), seismic (Kepler), and spectroscopic constraints, in the attempts of cataloguing as many low-mass binaries hosting one or two Red Clump stars as possible. Despite the long evolutionary timescales of the clump phase, we expect to observe only a very limited amount of these systems. This is mainly due to binary interaction between the two stars when one of them reaches the tip of the Red Giant Branch and undergoes the He flash. Finding, characterizing, and determining the overall number of these systems can put strong constraints on the physics involved in binary evolution, as well as more broadly on stellar evolution, at an evolutionary phase that is still very hard to simulate with current modelling codes. Additionally, for a small subset of these systems it will be possible to extract individual oscillation frequencies for both stars. This would, in turn, enable single-system studies targeting aspects of stellar physics that can typically only be explored when using large mono-populations, e.g. clusters.

P42

Title: Discovering g- and p-mode pulsators in the TESS-PLATO Field-of-View with machine learning

Author: Jeroen Audenaert
Affiliation: MIT

Abstract: The millions of light curves that are being delivered by TESS contain an incredible amount of information for asteroseismology. The first step in uncovering this information is to identify the pulsating stars in the data set. We therefore constructed a machine learning classifier to hunt for p- and g-mode pulsators in TESS. We updated the training set from the TESS Data for Asteroseismology (T'DA) Working Group and optimized the classifier for the 10-min Extended Mission 1 (EM1) and 200-sec Extended Mission 2 (EM2) light curves. In this talk, we will focus on the TESS light curves in the Southern Hemisphere, and in particular on the ones in the first observing field of the upcoming ESA PLATO mission (launch 2026). We will specifically discuss our classifications for the half a million light curves in the g- and p-mode temperature regime in this field. The classifications are of key importance for the community as the PLATO satellite will only send back the observations for a pre-selected list of targets. Hence, our TESS classifications will allow the asteroseismic community to create an optimal selection of targets to follow-up with PLATO. This project is the first part of our full-sky TESS stellar variability catalog.

P43

Title: Improved Period Estimates of RR Lyrae Stars using Multi-Tapering and the F-Test

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Abstract: Obtaining period estimates of RR Lyrae stars often requires a multi-step process (e.g., Lomb-Scargle periodogram followed by refinement steps to converge on the best estimate of the period). In this talk, I will discuss a new technique we have discovered to acquire accurate pulsation frequencies for RR Lyraes in a more efficient and reliable way. The method uses mtNUFFT, an extension of the Thomson multitaper power spectrum estimator to quasi-even time-sampling, along with the F variance ratio test, to estimate the periods. In this talk, I will introduce this approach and demonstrate its effectiveness on a sample of 44 RR Lyraes from TESS. I will then demonstrate that overall, the F variance ratio test outperforms the Lomb-Scargle Periodogram in both accuracy and computational efficiency. In particular, we see obvious improvements on period estimates in the phase-folded light curves of the RR Lyraes compared to literature values. The software for our new approach is available in an open-source software package, which should be useful not only for RR Lyrae, but also for other studies of stellar pulsations.

P44

Title: Spectroscopic Analysis of roAp star HD 60435: Determination of the Rotation Axis Inclination

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Co-authors: Simon J. Murphy (1); Duncan Wright (1)
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Abstract: We present a spectroscopic study of roAp star HD60435, which ceased pulsating in the last few years. To accurately model a magnetic star's pulsational behaviour, we need to determine the inclination of the rotational axis to constrain possible geometries. This study contains a detailed vsini analysis based on an extensive spectroscopic dataset. HD60435 was observed with the high-resolution (R=80000) Veloce spectrograph on four nights across six months. Our observations indicate no evidence of binarity, as there are no double-line profiles, and the radial velocity remains constant. We determined vsini with MCMC profile fitting, including the intrinsic stellar profile (consisting of temperature, micro- and macro-turbulence), instrumental broadening and rotational broadening. The fitting process was conducted on a single Fe I line at 543.45 nm, as it is well isolated, insensitive to magnetic broadening, and on a weighted average of LSD profiles. There is no significant difference between the two and no evidence for additional broadening mechanisms in LSD profiles, resulting in a determined value of 11.3+/-0.5 km/s, with a standard deviation of 0.05 km/s for individual exposures. Further analysis of atmospheric parameters follows with Teff, logg, and [Fe/H] determined from well-isolated Iron lines. These parameters were used to proceed with the determination of individual abundances.

P45

Title: Resolving an Asteroseismic Catastrophe: What do Red Giant Small Separations Signify?

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Co-authors: Christopher Lindsay (1); Claudia Reyes (2); Dennis Stello (2); Ian Roxburgh (3)
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Abstract: On the main sequence, the small frequency separation $\delta\nu_{02}$ between radial and quadrupole p-modes is customarily interpreted to be a direct diagnostic of internal structure. Such an interpretation is based on a well-known integral estimator relating it to a radially-averaged sound-speed gradient. However, this estimator fails, catastrophically, when evaluated on structural models of red giants: their small separations must therefore be interpreted differently. We derive a single expression which both reduces to the classical estimator when applied to main-sequence stellar models, yet reproduces the qualitative phenomenology of the small separation for stellar models evolving up the red giant branch. This expression indicates that the small separations of red giants scale primarily with their global seismic properties as $\delta\nu_{02} \propto \Dnu^2/\numax$, rather than being in any way sensitive to their internal structure. Departures from this asymptotic behaviour have been recently reported in open-cluster JCD diagrams from the K2 mission, during the transition between these two regimes. Investigating them in detail, we demonstrate that these deviations occur when convective envelope boundaries pass a specific acoustic distance from the centre of the star. The shape of the corresponding features on cluster JCD diagrams may be useful in constraining the nature of convective boundary mixing, in the context of undershooting beneath a convective envelope.

P46

Title: Revisiting the (in)feasibility of Gravity-Mode Structure Inversions

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Co-authors: Willem Hoogendam (1)
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Abstract: While linear inversions have historically been highly successful in permitting the interior structures of p-mode solar-like oscillators to be inferred in detail, the direct and unmodified application of these techniques to g-mode oscillators, such as SPB stars, has recently met with less success. This has claimed to be fundamentally caused by nonlinear phenomena limiting the applicability of such techniques. These nonlinearities have so far been described as avoided crossings between these g-modes, and waves trapped by local enhancements in the Brunt-Vaisala frequency. We demonstrate, however, that they are potentially better described as buoyancy glitches, rather than avoided crossings, since the local enhancements in the buoyancy frequency often yield no supernumerary modes. Conversely, we show that techniques developed for describing avoided crossings in other seismic contexts also require the inclusion of higher-order terms to describe these glitches, and are thus unhelpful for the inversion problem. Analogous acoustic glitches in solar-like oscillators pose no major impediment to the use of such inversion techniques, suggesting that these buoyancy glitches may likewise not fundamentally limit g-mode inversions. We describe specific modifications of the inversion methodology to the properties of g-modes in particular — overlooked in earlier studies — that are necessary to render g-mode inversions well-conditioned, and discuss the remainining limitations of the technique.

P47

Title: APO-K2 and APOKASC-3 asteroseismic ages across the Galaxy

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Abstract: The APO-K2 and APOKASC-3 catalogues together constitute the largest spectro-asteroseismic datasets in the literature, containing over 7,000 and 12,000 evolved stars with asteroseismic ages and spectroscopic abundances. Here, we describe the properties of these datasets and their relative strengths, with an eye toward Galactic archaeology applications. APOKASC-3, with its high-precision data, features clear upper limits to the ages of the thin and thick discs and promises useful red clump ages. APO-K2, with its well-defined selection function, is corroborative of semi-analytic models for the chemical evolution of the Galaxy and offers insights into the age distributions of halo substructures.

P48

Title: The early life of the Sun and solar-like stars

Author: Johannes Holm Jørgensen
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Abstract: Since the advent of space-based photometry missions, asteroseismology of solar-like oscillators on the main-sequence and the red-giant branch has proven crucial for inferring their interiors. Solar-like stars in their pre-main sequence evolutionary stages are theoretically predicted to show stochastically excited oscillations as well, hence motivating the search for a "young Sun". Finding a solar-like oscillator on the pre-main sequence is the first step in unraveling how our own Sun was during its earliest evolutionary stages. Identifying such oscillations, as a power-excess in the Fourier domain of the light curves, is challenging as the availability of data for pre-main sequence solar-like stars is limited and as the high stellar activity of young stars, with strong magnetic fields and spots, can dampen the oscillations to the point where they are not detectable. We use the software APOLLO (Müllner et al. 2021), a Bayesian framework for fitting power-spectra, to detect this power-excess and quantify its presence. Additionally, we built a grid of accreting pre-main sequence stellar models to improve the theoretical predictions for young Suns. Our results so far include a sample of pre-main sequence solar-like oscillator candidates and first estimates of the parameter space in which they reside. With our models we can also predict their internal structure.

P49

Title: A grid-based machine learning tool for inferring exoplanet host-star properties

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Abstract: Uniform inference of exoplanet-host star parameters (such as mass, radius, and age) taking into account the relevant stellar physics is essential in the robust characterisation of planetary systems. This is attributed to the strong synergy between planets and their host-stars. In this poster, we present a machine learning tool which accurately and precisely infers exoplanet host-star parameters, based on available set of atmospheric constraints. The tool rapidly trains on a set of theoretical model observables, delivering instant estimates of stellar parameters. The results from our machine learning tool are consistent with stellar properties of binary stars, LEGACY sample, and sun-like main-sequence stars in the APOKASC catalogue. In particular, our code yield systematics for the binaries of up-to 2.3% in radius and 5.1% in mass. For the LEGACY sample, the systematics in radius, mass, and age are 1.6%, 3.3%, and 14.8%, respectively. Therefore, the tool can be adopted in uniformly deriving stellar properties of a catalog of exoplanet-host stars.

P50

Title: Cepheids with GATS project

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Abstract: The main objective of the project was to determine the atmospheric parameters for several Cepheids observed by the telescopes of the Global Astrophysical Telescope System (GATS). The GATS project aims to establish a network of robotic telescopes equipped with spectroscopes and state-of-the-art cameras. The primary goal of the project is high resolution stellar spectroscopy (R~35 000 - 40 000). The system consists of 3 telescopes; two of them are used for spectroscopic observations: telescopes PST1 and RBT. PST1 (Poznań Spectroscopic Telescope) has been operational since August 2007 at the Borowiec Astrogeodynamic Observatory (near Poznań), while RBT (PST2) has been operational since autumn 2013 at the Winer Observatory (Arizona, USA). GATS has focused on observing pulsating variable stars - Cepheids. Our observations cover several years, providing extensive datasets suitable for studying long-term variability and obtaining spectra with high SNR. In our poster presentation, we will present the preliminary spectroscopic analysis of spectra obtained for several Cepheids observed by our telescopes. This analysis will be based on averaged spectra with an S/N ratio greater than 100. To estimate atmospheric parameters (effective temperature, surface gravity, metallicity etc.) from iron lines (Fe I and Fe II), we used the iSpec program and the spectrum synthesis method with ATLAS9 Kurucz/Castelli models. For selected objects, we also determined the abundances of individual elements

P51

Title: Unveiling Stellar Nature Through Oscillation Pattern Recognition

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Abstract: Asteroseismology is a pivotal observational method of stellar physics, allowing for the characterization of stars based on their oscillation properties. In recent years, supervised machine learning algorithms have aided in stellar characterization as a powerful tool to categorize evolution based on interior oscillations. In this study, we use an unsupervised machine learning algorithm, coupled with data clustering techniques, to classify red giant stars using 2D asteroseismic data represented as images. With our classification of ~6000 (6381) Kepler red giants, we automatically identified stars belonging to the red giant branch, the red clump (core Helium-burning), and for the first time with automatic methods, the secondary red clump (non-degenerate core Helium-burning) as well as stars with low-amplitude power in their oscillation spectra. This iteration of the method has high agreement with previous classifications, where the red giant branch and core Helium-burning stars show 98.879% and 85.038% agreement, respectively. Among the core Helium-burning stars, 18.584% are secondary red clump stars, and among the red giant branch, 7.506% of them are low amplitude stars. As we are in an age dominated by large amounts of data to be analyzed in stellar physics, our automatic classification method shows promise in being capable and reliable to analyse millions of stars observed by Kepler, TESS, and PLATO.

P52

Title: High degree l modes in a delta Scuti star

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Abstract: We report on a spectroscopic and photometric study of the delta Scuti variable star sigma Octantis, which has been reported to be a hybrid delta Scuti /gamma Doradus star previously. An large set of 350 high resolution spectra were obtained with the 1-metre McLellan Telescope and HERCULES spectrograph at the University of Canterbury Mt John Observatory and these have been supplemented by an analysis of an extensive data set of photometric observations obtained during four Antarctic winters, as well as several TESS sectors of observations. From the spectra, a value of 100 km/s was obtained for the vsini. Spectroscopically 68 statistically significant frequencies were identified; 57 of the δ Scuti type, 8 of the γ Doradus type and three which fell outside the lower bound of the γ Doradus frequency range. Many of the dominant frequencies are also seen in the photometry, and variable amplitudes of some modes are noted. Extensive modelling of a selection of frequencies was carried out. All models were of prograde pulsations of high degree ($l \geq 9$) and many were largely sectoral modes. No evidence for a radial mode pulsation was found.

P53

Title: Giant stars 2.7 times as massive as the Sun: Shaking, but not stirred!?

Author: Karsten Brogaard
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Abstract: As is well-known James Bond takes his Martini shaken, but not stirred. Little did he know that astronomers would ever use a similar phrase to describe stars. However, now we are doing just that. We studied giant stars with solar-like oscillations – hence the “shaking” – in two specific young open star clusters NGC6866 and NGC6633. Surprisingly, the mixing processes in the stellar interiors have been much less effective than predicted by current 1D stellar models with rotation – hence the “not stirred!” The evidence is missing effects on stellar evolution and structure, as well as on chemical mixing as seen in [C/N] ratios and the abundance of Lithium.

P54

Title: Eclipsing binaries with a giant solar-like oscillator

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Abstract: We report on our on-going observations of all currently known eclipsing binaries with a giant solar-like oscillator in the Kepler field as well as candidates in the K2 field. These targets provide important test of asteroseismology and the mass- and distance scale.

P55

Title: Seismology and modeling of the bright, wide eclipsing binary, gamma Persei

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Abstract: Gamma Persei is a naked-eye, very wide binary system, in which eclipses occur every 14.6 years. Unlike the 1990 and 2019 eclipses, the 2005 one was not observed due to the star's proximity the Sun. However, we were able to extract the eclipse from the space-based SMEI observations. More recently, TESS observed the star in two sectors so far, and by pure coincidence, one of those included the 2019 eclipse of the system. Although the primary star is a large red giant, which makes its oscillation frequencies very low, we were able to estimate nu_max for it. From that, we estimate the mass of the primary to be about 3 solar masses, based on scaling relations. We then modeled the the system with the PHOEBE code, fitting historical radial velocity measurements and multicolor and TESS photometry of the eclipses. We also investigated the visibility of the secondary eclipse. Previous estimates of the primary's mass varied between 2.5 and 3.5 solar masses, and physical parameters suggested the possibility of the components being not co-eval, i.e., one of them being a merger product. We use MESA isochrones to test whether the physical parameter ranges based on the seismic and binary model constraints can be co-eval, or if a merger scenario is required.

P56

Title: Analysis of variations in oscillations above the acoustic cut-off frequency for 91 Kepler stars

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Abstract: Stellar oscillations with frequencies greater than the acoustic cut-off are not trapped within the star's interior. Geometric interference between these high-frequency waves produces a peak-like structure in the power spectrum of the star, known as the pseudo-modes. In this work, we first aimed to detect the pseudo-modes in a sample of 91 Kepler stars. Bootstrapping was used to determine the significance of peaks in the power spectrum of the power spectrum (PSxPS). 54 stars displayed a statistically significant peak (<5% false alarm probability) in their PSxPS. Then, we analysed these 54 stars for temporal frequency shifts, obtaining the shifts and uncertainties with the resampled periodogram approach. For each star, we created periodogram realisations from successive, overlapping 90-day time segments and generated a cross-correlation function between them. Of these stars, 52 have a maximum variation in their frequency shifts greater than 3σ. Shifts were also compared with temporal p-mode frequency shifts and the photospheric activity proxy, Sph, where, for 13% of our sample, pseudo-mode frequency shifts were significantly anti-correlated with p-mode shifts, as is the case in the Sun. However, we also found pseudo-mode and p-mode shifts to be significantly correlated in phase in 6% of our sample. We further compared pseudo-mode maximum frequency shift variation to stellar parameters and found variations to be significantly larger for cooler, older, and slower rotating stars.

P57

Title: Spectroscopy and asteroseismic modelling of the red giant binary system KIC 10841730

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Abstract: Stellar modelling is crucial for understanding the structure and age of stars. The accuracy of a stellar model is limited by the constraints from observations and the theory behind the physical processes. Gravitationally bound stars of a binary system provide an excellent opportunity for a combined study, which provides strong constraints on the stellar models. Due to their shared origin, both stars share the same age and initial chemical composition. Combined with spectroscopy and radial velocity measurements it is additionally possible to determine the mass ratio. Such a binary system is particularly promising if both stars are oscillating. The detected oscillation modes give valuable insights into the internal structure and evolutionary state of the stars and complement a detailed modelling analysis. KIC 10841730 is a great example of such ideal conditions. The binary system consists of a helium-burning red giant clump star and a red giant branch star. Both stars are oscillating and were observed with high-resolution spectrographs. We use this wealth of information to test parameters like the mixing length, mass loss and different methods to account for surface effects and demonstrate the high potential of such systems to study ill-constrained effects in the red-giant phase of evolution.

P58

Title: A model of rotating and magnetised convection in stellar and planetary interiors

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Abstract: Convection plays a pivotal role in stellar astrophysics, as it serves as a fundamental mechanism for transporting energy, and in turn influences the stars' structures and evolution. A monomodal approach of convection, the Mixing-Length Theory, is often used and implemented in 1D stellar evolution codes. However, it neglects the combined impacts of rotation and magnetic fields, which are nevertheless of keen importance in stars. To address this limitation, we extend the Mixing-Length Theory for stellar and planetary convection, taking into account both rotation and magnetic fields. We show that both phenomena tend to inhibit convection, and we account for the magnitude of the root-mean-square (rms) velocity, characteristic length scale and degree of superadiabaticity depending on the rotation rate and magnetic field strength. In a second time, we apply those results to estimate how rotation and magnetic fields influence the convective penetration length between convective and stably stratified regions of stars.

P59

Title: Spectroscopic observations and space photometry of TIC 171084337

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Abstract: We present ground-based spectroscopy and space photometry of TIC 171084337 (HD 282258, BD+30 672, GSC 02373-01883), a short-period semi-detached binary of spectral type A0-B9. The star was observed by TESS in 7 sectors with an exposure time of 120 seconds. Analysis of the TESS data reveals an orbital period of 0.41 days, consistent with previous studies. Spectroscopic observations were conducted at the Observatorio Astronómico Nacional en San Pedro Mártir (OAN-SPM) in Baja California, Mexico between 2021 and 2022. A total of 35 spectra were obtained using the Echelle REOSC spectrograph attached to the 2.1m telescope. Atmospheric parameters such as effective temperature (Teff), surface gravity (log g), and projected rotational velocity (v sin i) were derived and found to be in good agreement with previous reports. Radial velocity analysis indicates that TIC 171084337 is a single-lined spectroscopic binary with the same orbital period observed in the TESS light curves. The Phoebe code was used to model the binary light curves, allowing us to derive the physical parameters of each component. To search for pulsations, a Fourier analysis of all available TESS data was performed after extracting the effects of binarity from the light curves. The results are discussed in this contribution.

P60

Title: Inferring the efficiency of convective-boundary mixing in Red-Giant stars

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Abstract: The comprehension of mixing processes in stars is important to reach a better understanding of the chemical abundances in stellar photospheres and of their variation with evolutionary phase. This is fundamental, for instance, for a more accurate estimation of the age of red giant stars from the C/N ratio. Among these mechanisms, overshooting is in dire need of a systematic calibration and comparison with predictions from 3D hydrodynamical simulations. The Red-Giant Branch bump (RGBb) is an ideal calibrator for overshooting processes, since its luminosity depends on the maximum depth reached by the convective envelope during the evolution of the star. Indeed, a more efficient overshooting produces a discontinuity in the Hydrogen mass-fraction profile deeper in the stellar interior and consequently a less luminous RGBb. In this work, we combined predictions of stellar models with observations, both of globular clusters and field stars in the Kepler field. We found a correlation between the overshooting efficiency and the global metallicity, which suggests a dependence of the former on the latter. This represents a first step towards developing more accurate stellar models, in which the overshooting efficiency depends on stellar properties rather than being treated as a free parameter, and whose predictions can be compared with those from 3D hydrodynamical simulations.

P61

Title: Influence of rotating magnetized convection on the evolution and stellar structure.

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Abstract: Observations of low-mass stars reveal that their radii are larger than predicted by standard 1D models of stellar structure; previous work has suggested that inefficient convective heat transport due to a magnetic field could be the cause. We investigate this issue using analytical arguments and 3D spherical magnetohydrodynamic simulations (MagIC/PaRoDy codes) to improve the convection modelling currently implemented in the 1D stellar evolution code Cesam2k20. In general, standard 1D models do not explicitly include the effects of the magnetic field or large-scale mean flows. 3D convective motions are modelled using ad hoc mixing length theory (MLT). We consider the effects of rotation on heat transfer efficiency by performing a stability analysis of the convection affected by rotation and mean flows. We then use our 3D simulations to include global rotation and the magnetic field in a modified version of the MLT formalism in 1D stellar evolution models. The magnetic fields and rotation lead to significant radius inflation. The latter makes convection less efficient, while the former requires steeper temperature profiles for convection to develop.

P62

Title: The turbulent Tayler-Spruit instability as an important mecanism for the transport of angular moment

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Abstract: Traditionally, the transport of angular momentum in stellar radiative zones (RZ) is modelled as the result of angular momentum advection by meridional circulation and diffusion of angular velocity through shear-induced turbulence. Clearly, the angular velocity (Omega) profiles obtained with this model do not agree with the observations. Indeed, the expected radial shear in the solar RZ is in complete contradiction with the results of helioseismic inversions, which show an almost rigid rotation. In more evolved stars, a radial differential rotation is inferred, but it is much smaller than that predicted by classical angular momentum transport. These discrepancies argue for the consideration of additional mechanisms that transport angular momentum. Diffusion induced by the Taylor-Spruit (TS) instability is one of the most promising candidates. Previous studies have shown that the TS instability is an efficient transport mechanism, but not sufficient to reproduce the observations. However, recent 3D simulations have shown that the TS instability induces more turbulence than predicted by analytical derivations. With this new formulation, the TS instability is able to better reproduce the angular velocities inferred in evolved stars.

P63

Title: Dips formation in the gravity-mode period spacing pattern: the magnetic picture

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Abstract: Understanding angular momentum transport is a major challenge for the stellar evolution theory. Recent asteroseismic studies from Kepler detected dips in the gravity modes period spacing vs period diagram of gamma-Doradus stars. One of the mechanisms resulting in such dips is the interaction of gravito-inertial modes in the radiative envelope with pure inertial modes in the convective core. In this work we derive the effect of internal magnetic fields on the Lorentzian shape of the dip, magnetic fields being one of the main serious candidates to efficiently redistribute angular momentum throughout stellar evolution. For this, considering a toroidal magnetic topology corresponding to a uniform Alfvén frequency in the radiative envelope and in the convective core, we study the waves behaviour in both regions and we demonstrate that the magneto-hydrodynamic coupling problem shows similarities with the pure hydrodynamic case. We identify the three main influences of the magnetic field: a shift of the average period-spacing in the co-rotating frame, an additional decrease of the period-spacing pattern in period and a shift of the period of the dip in the inertial frame. We extend the study to non-Kelvin modes previously detected in gamma-Dor. Our work demonstrates the remarkable potentiality of studying such dips to probe internal stellar magnetism and provides predictions for further future detection in asteroseismic data.

P64

Title: From the photometric signatures of starspots to new observational constraints on the stellar dynamo

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Abstract: The study of stellar magnetism is crucial in order to understand the mechanisms and evolution of the global magnetic fields of the stars. These fields are governed by the dynamo effect, a phenomenon that still need to be better understand. We propose a characterization of this magnetism through different stellar parameters (mass, rotation, Rossby number, etc …) for low mass stars by using a new description of the light curve power spectra. We use photometric activity as an observable to investigate the characteristics of stellar spots (area, lifetime, …). By analysing the Fourier domain of light curves and revisiting the model introduced by Harvey et al. (1985) to encompass all spectral components, we find two activity proxies: the spot impact proxy (link to spot coverage and temperature) and the spots lifetime. After validating this model with simulated light curves, we present the results from thousands of Kepler light curves of main sequence stars used by McQuillan et al. (2014) and Santos et al. (2022). We also put these results into perspective with the LAMOST activity observations. The results show the emergence of three different types of activity linked to these two proxies. They are each related to different star's properties — and more precisely to 3 different Rossby numbers — which can provide information about the stellar dynamo.

P65

Title: Unsupervised Classification of RR Lyrae Stars

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Abstract: Big Datasets are becoming increasingly important in astrophysics due to new surveys continuously observing our night sky. A prominent example of an observatory that will produce a large data stream is Vera C. Rubin LSST, designed to simultaneously monitor the southern night sky in 6 colors. Unsupervised machine learning (ML), a method of learning from patterns within the data, is key for gaining insight into this expansive photometric data. We present our prototype classifier dedicated to classifying RR Lyrae variable stars into their relevant subclasses (RRab, RRc, and RRd). Using the RR Lyrae Catalog of the ESA Gaia mission, we constructed training sets containing ~30000 lightcurves using data from the Zwicky Transient Facility Catalog of Periodic Variable Stars (ZTF CPVS) and lightcurves extracted from Full-Frame-Images of the NASA TESS space telescope. Using a Variational Autoencoder (VAE), we project the processed lightcurves into a low-dimensional representation, which quantitatively describes the characteristic shape elements of the lightcurves. In preparation for Rubin LSST, we applied our pipeline to ZTF, a precursor facility for Rubin LSST. We show how the ML results are improved by including physical features such as period and variation amplitude. Through unsupervised clustering of this data representation, we identified the RR Lyrae subclasses in the ZTF data, which we anticipate to be easily adaptable to Rubin LSST.

P66

Title: sigma Draconis: The coolest nearby star with asteroseismology from the Keck Planet Finder and TESS

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Abstract: Asteroseismology of dwarf stars cooler than the Sun is very challenging due to the low amplitudes and rapid timescales of oscillations. Here, we present the asteroseismic detection of solar-like oscillations at 4-minute timescales in the nearby K-dwarf sigma Draconis using extreme precision Doppler velocity observations from the Keck Planet Finder and 20-second cadence photometry from NASA's Transiting Exoplanet Survey Satellite. The star is the coolest dwarf to date with asteroseismic observations from both ground and space. The measured oscillations show excellent agreement with established luminosity-velocity amplitude relations and provide further evidence that mode amplitudes for stars cooler than the Sun scale more steeply with stellar luminosity than expected. By modelling the star's oscillation frequencies from photometric data, we measure an asteroseismic age of 4.5 Gyr, in agreement with values from literature. These observations demonstrate the capability of next-generation spectrographs and precise space-based photometry to extend observational asteroseismology to nearby cool dwarfs, which are benchmarks for stellar astrophysics and prime targets for directly imaging planets using future space-based telescopes.

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Title: SMALL SEPARATIONS IN RED-GIANT STARS: QUEST FOR LATE-EVOLUTION SIGNATURES USING ASTEROSEISMOLOGY

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Abstract: This work is dedicated to the exploration of the small frequency separations in red-giant stars, an asteroseismic parameter that comes from the analysis of the oscillation spectra of the stars. Our study focuses on two phases of red giant stars: the red giant branch (RGB) stars and the red clump (RC) stars, while in the first the core helium burning did not occur yet, in the second is active. These two stages overlap in the HRD, making it difficult to discern between them. It is possible to partially solve this issue using the period spacing of the gravity modes, which, unfortunately, requires high quality data to be measured. In order to understand the relevance of the poorly studied small frequency separation on distinguishing between RGB and RC stars, a ML tool was applied to measure this impact, several tests were done on synthetic stellar samples with classic (Teff, L and Fe_H) and asteroseismic (large and small frequency separation and frequency at maximum power) parameters. The first one consists in using different input parameters (with and without the small separation) and comparing the values of the performance, in our case was the accuracy, the informedness and the AUC score.The second test was done by using the feature importance based on the method applied. We are dazzled to announce that from the 4 input features groups (with the small separation), there are 2 of them where the small frequency separation plays the highest impact on the stellar classification.

P68

Title: On exoplanet habitability by merging asteroseismic and stellar magnetic activity measurements

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Abstract: We present our synergic strategy that merges the potential of asteroseismology with solar space weather techniques and orbital evolution modelling in order to characterize solar-like stars and their interaction with hosted exoplanets. Our investigation allows us to obtain not only a highly accurate characterization of the mother star, but also to study the impact of the host star's rotational and activity history on the evolution of its exoplanets. This information, coupled with the precise age estimate by asteroseismology, determines how long an atmosphere could resist the action of stellar wind, X-ray and EUV luminosity, directly quantifying the portion of the atmosphere that could be eroded.

P69

Title: Properties of observable mixed inertial/gravito-inertial modes in γ Doradus stars

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Abstract: In γ Doradus stars, gravito-inertial modes in the radiative zone and inertial modes in the convective core can interact resonantly, which translates into the appearance of dip structures in the period spacing of modes. We aim at characterising these dips according to stellar properties and thus developing new seismic diagnostic tools to constrain the internal structure of γ Dor stars, especially their core. We used the two-dimensional oscillation code TOP to compute modes in γ Dor stars at different rotation rates and evolutionary stages. We then characterised the dips we obtained by their width and location on the period spacing diagram. We found that the width and the location of the dips depend quasi-linearly on the ratio of the rotation rate and the Brunt-Väisälä frequency at the core interface. This allowed us to determine empirical relations between width and location of dips on the one hand, and on the other, resonant inertial mode frequency in the core and Brunt-Väisälä frequency at the core/radiative zone interface. The empirical relations we established could be applied to dips observed in data, which would allow for the estimate of frequencies of resonant inertial modes in the core and of the Brunt-Väisälä jump at the interface between the core and the radiative zone. As those two parameters are both related to the evolutionary stage of the star, their determination could lead to more accurate estimations of stellar ages.

P70

Title: Epsilon differences, an improved surface-independent asteroseismic method

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Abstract: With the great inference power asteroseismology brings to model fitting of stars, one of the greatest challenges is the asteroseismic surface effect. While it has previously been circumvented using combinations of individual frequencies, most often the frequency separation ratios, they are derived using several approximations which decreases the precision of the inferred parameters. Here, we present the epsilon differences method, which utilizes how specific combinations of individual frequencies cancel out the contribution from the surface, derived using less approximations than frequency separation ratios, and how it performs in comparison to the established methods.

P71

Title: EGGMiMoSA as a way to unveil Gemma's (KIC11026764) convective history

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Abstract: With our seismic diagnostic tool for subgiants, EGGMiMoSA (Farnir et al. 2023), we are able to precisely retrieve seismic indicators that hold relevant structural information. By carrying an accurate modelling with such indicators as constraints, we can demonstrate that Gemma could not have harboured a convective core during its main sequence phase. These findings are crucial to the help better understand the processes at hand that redistribute angular momentum in these evolved stars. Indeed, Deheuvels et al. 2014 observed that subgiant's cores rotate much slower that would be expected through simple conservation of angular momentum in these phases. Additional redistribution mechanisms are therefore necessary. Our findings shed some new light on such processes.

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Title: PBjam 2.0

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Abstract: PBjam is an open source package for Python meant as an easily accessible way to peakbag solar-like oscillators. With the latest update, PBjam is able to perform automatic mode identification of angular degree l=0, 1 and 2. PBjam we utilises a large set of previous observations of model parameters to construct a prior probability density which is tuned to the star in question. This allows us to evaluate the likelihood of a generative model given the power density spectrum of a star observed by for example Kepler or TESS, thus providing a confidence interval for the mode frequencies. The dipole modes are particularly difficult to identify unambiguously for a wide range of evolutionary phases, and so we provide three models which are intended for main sequence, sub giant and red giant stars respectively. This first consists of a simple asymptotic model for pure p-modes, while the sub giant and red giant models provide more elaborate treatment of the dipole mode frequencies to account for the possible frequency-dependent coupling to the g-mode oscillations in the stellar core. The resulting mode identification can then be passed to the final stage of the peakbagging process, where the constraints from the prior are released, allowing PBjam to capture more detailed variation in the mode frequencies. This process requires minimal input from the user, decreasing the barrier to entry for exploiting the data provided by Kepler and TESS, and the future Plato mission.

P73

Title: Exoplanet Occurrence Rate with Isochrone Ages for FGK Stars in Kepler

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Abstract: We measure planet occurrence rate as a function of stellar isochrone age using the confirmed and candidate planets identified by the Q1-17 Kepler pipeline search. We employ Kepler's pipeline detection efficiency to correct for the expected number of planets in each age bin. We examine the occurrence rates for 942 planets with planet radii $0.2 \leq Rp \leq 20$ Earth radii and orbital periods $0.2 \leq P \leq 730$ days for FGK stars with age ≤ 9 Gyr using the inverse detection efficiency method. We mostly see a flat trend in the exoplanet \orate with stellar age, which could be attributed to the large uncertainty in isochrone ages, or the small sample size, but find tentative evidence for a dropoff in exoplanet occurrence at ~5 Gyr. We further investigate the relationship with stellar mass and metallicity, and although we find a decreasing trend between exoplanet occurrence rate and stellar age for low mass (0.8-1.0 solar masses) and low metallicity (-0.5-1.0 dex), the uncertainties on the occurrence rate are consistent with a flat trend. Overall, our results suggest that exoplanet system membership does not change appreciably between 0.5-9 Gyr; any planets lost -- due to dynamical instability from multi-planet systems via planet-planet scattering, or from stellar fly-bys via planet ejection -- occurs earlier in the system lifetime.

P74

Title: Characterisation of stochastic low-frequency variability in 50 massive stars

Author: May Gade Pedersen
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Co-authors: Lars Bildsten

Abstract: The advent of photometric space telescopes has revealed that stochastic low frequency (SLF) variability is a common type of variability found in massive stars. Here we analyse the TESS data for 50 massive stars showing SLF variability; 49 of which are found across six different Cygnus OB associations and one from the Small Magellanic Cloud (SMC). The SLF signal is characterised using two different methods and compared to a sample of 53 O- and B-type stars which have previously been studied in the literature. We find that SLF variability of the lower metallicity SMC star shows similar characteristics as the 102 galactic stars. Furthermore, we find a significant correlation between the spectroscopic luminosity of our sample of 49 Cygnus OB stars and the amplitudes and slopes of their SLF variability, while no similar significant correlation is found for the characteristic frequency.

P75

Title: Probing time dependent convective boundary mixing with gravity mode oscillations

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Abstract: One of the dominant uncertainties in the evolution of stars with convective cores arises from their poorly constrained internal mixing properties. Such mixing can renew the hydrogen fuel in the stellar cores, thereby significantly extending their main-sequence lifetimes and increasing the final helium core mass obtained at core hydrogen exhaustion. Different mixing processes occurring near convective boundaries are collectively referred to as convective boundary mixing (CBM). Their implementation in 1D stellar structure and evolution codes generally rely on at least one free parameter that defines the extent and mixing efficiency in this region. One such type of CBM is convective penetration. Recently, 3D numerical simulations of convective penetration occurring at the boundary of convective cores suggest that the extent of this CBM region can be directly computed from the properties of the core and changes size as the star evolves. Here we investigate if gravity mode oscillations, which have their highest probing power near the convective core, are sensitive to such time dependent CBM.

P76

Title: Tally of exoplanet host stars showing a seismic signal

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Abstract: Most studies of exoplanets rely on precise stellar parameters. An attractive way to obtain these is through asteroseismology, provided the host star shows oscillations that can be analysed. However, both the number of detected exoplanets and the number of pulsating/oscillating stars are rising continuously, causing an updated list of seismic host stars and their properties to be overdue. As a consequence, we are now assembling this updated catalogue of pulsating/oscillating stars that host confirmed and/or candidate exoplanets, and we need your help to ensure that we have included your asteroseismic host star in the sample. We will revisit the seismic detection of the solar-like oscillators and perform grid-based modelling of stars in the sample using the BASTA code.

P77

Title: The Convective Overshoot Conundrum: Implications in the Modeling of Subgiants Stars

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Abstract: Tests ran on classical interpolation algorithms using stellar subgiant grids with the typical resolution have revealed the algorithms' inadequacy in retaining l=1 mode frequencies within the precision expected from long-term space-based observations (~0.1 μHz). The interpolation errors are particularly concerning in the case of the mass-tracks associated with the transition between radiative and convective cores during the main-sequence. In this case, they are systematic thoughtout all of the subgiant phase, reaching maxima of 7.5 μHz. In this poster, we show that these large systematic errors stem from the drastic change in the core structure in adjacent mass tracks when the interface between convective cores and radiative interiors during the main-sequence is modelled by an exponential diffusive overshoot with a convective core overshoot parameter, f_ov. Moreover, we discuss how the convective overshoot parameter f_ov influences interpolation on a typical grid of subgiant models, and how the problems created by less-educated guesses of its value can be improved on. Additionally, we explore the possibility of creating a grid of subgiant models where f_ov is dependent on the mass, as discussed in Claret & Torres (2018), and highlight the benefits associated with this approach.

P78

Title: Darlings in the Sky

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Abstract: We present the initial asteroseismic detections for the "Darlings" sample, comprising bright (V<6) stars on the main-sequence or sub-giant branch observed by TESS.

P79

Title: Asteroseismology of Ruprecht 147

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Abstract: We present initial results from the asteroseismic analysis of stars in the open cluster Ruprecht 147, observed during the K2 mission.

P80

Title: Asteroseismology of pulsating ultramassive white dwarfs

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Abstract: Ultra-massive white dwarfs (UMWDs) are expected to harbor oxygen-neon (ONe) or carbon-oxygen (CO) cores, depending on the previous history of their progenitors. These stars serve as excellent targets for studying various phenomena, including type Ia supernovae explosions, merger events, and the existence of high magnetic fields. In addition, they provide an excellent opportunity to test the crystallization theory. Asteroseismic studies on these objects would allow us to shed light on their inner chemical structure and then, on the history of their progenitors. In this project, we conduct a photometric survey using OSIRIS and HiPERCAM, both attached to the Gran Telescopio Canarias (GTC). The primary objective is twofold: to significantly expand the known pop- ulation of pulsating UMWDs and to perform a comprehensive asteroseismological analysis of each detected pulsating UMWD, employing updated theoretical evolutionary/pulsational models. We expect to be able to obtain their seismological masses, effective temperatures, surface gravities, and the most important features of chemical structure of UMWDs. Our preliminary results reveal the existence of variability of two pulsating UMWDs within a sample of 13 stars. As our ongoing effort continues, we anticipate further discoveries. The high-quality data obtained from the GTC, complemented by observations from space missions such as TESS and PLATO, offers invaluable insights for advancing asteroseismological studies of UMWDs.

P81

Title: Discerning internal conditions of pulsating hot subdwarf B stars

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Abstract: Hot subdwarf B (sdB) stars are evolved, subluminous, helium-burning stars, most likely formed when red-giant stars lose their hydrogen envelope via interactions with close companions. They play an important role in our understanding of binary evolution, stellar atmospheres, and interiors. Among sdBs, only a small fraction pulsate. Recent space missions, notably Kepler, then K2, and now TESS, have revolutionized our comprehension of sdBs and have provided unprecedented access to asteroseismic measurements and tools for pulsating sdB stars. In this poster, we present a study that delves into convective boundary treatment during the helium-burning phase, with a particular focus on the convective premixing method and its impact on the evolution of the convective core in the pulsating sdB star, KIC10001893, which was extensively observed by the Kepler spacecraft. We identify three distinct stages in the convective premixing approach, and our analysis of asteroseismic characteristics and modeling of period spacings reveal the mode trapping due to compositional changes near the core. Our research explores various parameters related to period spacings across different stages of helium burning and suggests that using the distance parameter, which represents the average distances between trapped modes during the second stage of sdB evolutionary models, is a viable approach for describing the core helium-burning phase.

P82

Title: Positive Unlabelled Learning to Discover Hybrid Pulsating Stars in the TESS Catalogue

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Abstract: Existence of stellar pulsations allows to use asteroseismology to learn about the interiors of stars that otherwise could not be discovered with classic observational methods. Hybrid pulsating stars that exhibit both pressure and gravity modes are of utmost astrophysical interest owing to the fact that joint interpretation of p- and g-modes in these stars tells us about their interior physics across the entire mass coordinate. Hybrid pulsators amongst OBAF-type stars are relatively rare. Automatic detection of rare stars in large astronomical surveys faces significant challenges of manual labelling for supervised and low interpretability for unsupervised machine learning methods. In this study, we propose Positive Unlabelled (PU) Learning as a semi-supervised learning setting for the identification of hybrid pulsators, which are crucial from the perspective of stellar structure and evolution studies. We work with QLP light curves, from which we remove instrumental noise and extract astrophysical frequencies. Next, we use PU-bagging to train an ensemble of decision trees (DTs). Each DT is trained using the entire positive and a bootstrapped sample of unlabelled light curves from a single TESS Sector. New positive candidates are found by selecting the unlabelled instances with the highest average out-of-bag scores. We validate the model by injecting the unlabelled set with known labelled non-hybrids and establish a probabilistic threshold on the final probability distribution.

P83

Title: Introducing an automated pipeline for the estimation of DeltaPi for solar like oscillators

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Abstract: Due to missions like KEPLER and TESS, large datasets with promising seismic data are now readily available. While the estimation of some seismic parameters can be automated, yielding satisfactory results, the automatic estimation of the period spacing proves to be problematic. We present a pipeline that can be used on datasets containing a large number of targets. The aforementioned pipeline automatically estimates key seismic parameters, the position of the central five l=0 and l=2 modes, and the position of safely detectable l=1 mixed modes. Our pipeline produces values for which DeltaPi lies >80% of the time in an interval of 5% around the literature value for a sample (N=450,M=2-3 solar masses). Furthermore, we achieved a result of 62% for another sample (N=3600,M=0.8-3 solar masses). We achieved this by identifying the frequency position of the five central l=0 peaks, eliminating them from the PSD and performing a peak search with differing prominences. We then assign a quality grade to each assumed dipole mode, by performing an R-value correlation test, which allows for the detection and rejection of likely misidentified modes. We make use of the asymptotic relation for the calculation of using an optimized version of the grid-search algorithm, resulting in a reasonable calculation time on the scale of seconds to minutes per target. While not as exact as the hands-on approach, our pipeline will prove useful if used on a large number of targets as an initial analysis.

P84

Title: Asteroseismic Analysis of Red Giants from TESS and K2 using Machine Learning

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Abstract: Our primary objective is to infer two global seismic parameters, the large frequency separation (Δv) and the frequency at maximum power (vmax), from one-month-long TESS observations of red giants. Meanwhile, for K2 data, our focus extends to inferring the period separation of g-modes (ΔΠ), in addition to Δv and vmax. The main challenge we encounter stems from the the lower frequency resolution of the power spectrum density (PSD) profiles derived from K2 and TESS data. This low resolution makes it difficult to accurately analyze PSD profiles using conventional methods. To overcome this limitation, we have adopted advanced machine learning techniques for asteroseismic analysis. Our findings demonstrate that our machine learning algorithm can accurately infer Δv and vmax for majority of the stars, even with just one month of observations. Moreover, for three-month-long K2 observations, we get accurate g-mode period separations for machine predictions with high confidence. For these high-confidence ΔΠ predictions from K2, we see a good match of the well known Δv−ΔΠ relationship when compared with Kepler red giants.

P85

Title: Unveiling the secrets of the 94 Ceti exoplanet-host system with TESS

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Abstract: Using TESS data, we revisited the full properties of 94 Ceti, a system of three stars. The system is composed of a main component, a naked-eye F-type star, orbited by two M dwarfs that, in turn, orbit each other. The main component also hosts an exoplanet. The study of this system has the potential of being a testing ground for a better understanding of the chemical evolution in planet-host F-type stars. The importance of chemical transport mechanisms in modelling the F-type star is the key to derive accurate fundamental parameters for all system components. We show the influence and efficiency of considering turbulent mixing and radiative accelerations treatments in the stellar models, which we have recently implemented in MESA. The new updated fundamental properties of the main component will also provide a new age for the M dwarfs, allowing them to be used as benchmarks. Finally, the binary relations inside of the system, derived by Gaia observations, will make possible an independent measurement of the masses of all the stellar components. In this study, we have extracted new seismic constraints from the TESS light curves of the F-type star. This allows us to update its fundamental properties which differ from the previous determinations of about 4% in mass, and 15% in age. The properties of the exoplanet are thus improved, showing a 7% difference in the mass compared to previous estimates.

P86

Title: Toward a comprehensive grid of Cepheid models with MESA I. Uncertainties of the evolutionary tracks

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Abstract: Helium-burning stars, in particular Cepheids, are challenging to model, as the shape of the evolutionary tracks can be greatly affected by the choice of free parameters of the model. MESA (Modules for Experiments in Stellar Astrophysics) is a one-dimensional stellar evolution code, that comes with a large number of free parameters that allow to model the physical processes in stellar interiors under many assumptions. The uncertainties that arise from this freedom are rarely discussed in the literature despite their impact on the evolution of the model. We calculate a grid of evolutionary models with MESA, varying several controls, like solar mixture of heavy elements, mixing length theory prescription, nuclear reaction rates, scheme to determine convective boundaries, atmosphere model, temporal and spatial resolution, and quantify their impact on age, effective temperature and luminosity at 8 different points of evolution, from the main sequence till the end of core-helium burning. Our investigation was conducted for a full range of masses and metallicities expected for classical Cepheids. The uncertainties are significant, especially during core-helium burning, reaching or exceeding the observational uncertainties of luminosity and effective temperature for detached eclipsing binary systems.

P87

Title: Emulating individual mode frequencies of Solar-like oscillators using a neural network

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Abstract: Characterising stellar fundamental parameters is difficult. For instance, generating new stellar evolutionary tracks to reflect observations is computationally expensive. Additionally, quantifying the uncertainty inherent in comparison to stellar model grids can be challenging. To mitigate this issue, we use a neural network as an emulator, converting discrete grids of stellar models into continuous functions with easily quantifiable emulation uncertainties. Once trained, this emulator is capable of rapidly predicting of a host of observable quantities including individual mode frequencies, each with easily quantifiable emulation uncertainties. Trained emulators are then used for likelihood estimation in Bayesian inference to recover plausible estimates of the posterior distributions. We present results for inferred fundamental parameters of solar-like oscillators. We observe that the recovered posteriors for simulated stars may exhibit non-Gaussian distributions, multimodality, and strong covariance. Furthermore, we present results obtained from real stars. Finally, we show how covariance in emulation prediction residuals should be accounted for, and discuss the improvements from using ensemble approaches to emulation in the future.

P88

Title: Constraining stellar and orbital evolution from the oscillating red-giant binaries revealed by Gaia

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Abstract: The evolution of stars and their hosting binary systems is a highly interactive process that cannot be investigated in a segregated manner. Due to the constraints drawn by stellar binarity, solar-like oscillators in binary systems represent a unique opportunity to study the details of the structure and evolution of stars in the advanced phases of stellar evolution. In this talk, we will discuss the results and lessons learned from the joint analysis of space photometry from NASA Kepler and TESS, ground-based high-resolution spectroscopy such as APOGEE, and astrometry and spectroscopy from space with the ESA Gaia satellite, which have significantly increased the sample size. From such an ensemble analysis, we show differences in the oscillatory behavior of tidally interacting systems between main-sequence and red-giant stars. Separating the binary systems by the evolutionary state of their primary shows the accumulated effects of the binary orbit evolution. This draws constraints on star-star interaction through tides, mass transfer, and a common envelope phase. Finally, we discuss the mystery of the missing eclipsing binaries in space photometry from Kepler and TESS and present the well-populated sample of astrometric binaries in PLATO’s Science Validation and Calibration (SVC1b) input catalog as an abundant alternative for well-defined benchmark objects to calibrate scaling relations and stellar models.

P89

Title: Science Calibration and Validation Targets for PLATO

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Abstract: The Science Calilbration and Validation (scv) Targets are required to calibrate stellar models (e.g., for age dating) and to test the exoplanet detection pipeline of PLATO. The scv targets bridge the PLATO Stellar Core Science and the Complementary Science. The discovery and inclusion of new and improved input physics descriptions and profiles in stellar models from the scv targets act as validation to minimize systematic uncertainties of mass, radius, and age of a star. The scv targets will also enable an assessment of how good or bad the chosen input physics description is allowing for a calibration of the free parameters. This is essential to reach the science goals PLATO aims to achieve. Many of the scv targets are part of PLATO's core program while the others are part of the Complementary Science. The scv targets are subdivided into six groups: binary stars, legacy and benchmark stars, photometrically stable stars, solar-like pulsators, gamma Doradus pulsators and known transiting exoplanets. At any given observing time some 2600 imagettes and some 27000 onboard light curves will be used for the scv targets. In this talk, we will present recent developments in the selection of the scv targets and the preparation of the Science Calibration and Validation PLATO Input Catalogue (scvPIC).

P90

Title: Calculation of the [α/Fe] from Stellar Evolution Models with Individual Altered Abundances of O, Ne, Mg, Si, S, Ca and Ti

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Abstract: Stars in newer generations form from an Interstellar Medium enriched in α-elements originating from Core Collapse Supernovae. Consequently, these stars exhibit an adjusted chemical composition, leading to distinct structural and evolutionary characteristics compared to stars in older populations. In this work we analyze how individual variations in the abundance of α-elements affect the physical properties of stars and we provide a calculation method of the [α/Fe] ratio from stellar models with individual altered abundances. For the calculation, we compute a grid of stellar evolution models, using GARSTEC, from the MS and up to the RGB for masses in the range 0.60 $\leq m/M_{\odot} \leq$ 2.00 and -2.60 $\leq$ [Fe/H] $\leq$ 0.60 with individual alterations of $\pm$0.20, $\pm$0.40 and ±0.60 dex in the abundances of the α-elements considered in this work, O, Ne, Mg, Si, S, Ca and Ti, based on observations from the APOGEE experiment from DR17 of the Sloan Digital Sky Survey. Using the grid of stellar models we are able to synthetically reproduce stellar tracks with altered α-elements abundances, and with these reproductions we calculate the [α/Fe] ratio from a minimization that involves lifetimes, $\log L/L_{\odot}$ and $\log T$ from stellar models and the chemical composition of the target star we want to reproduce. We test our calculation method with chemical data from 6 target stars in the APOGEE experiment. We analyze the dependence on the stellar mass and [Fe/H] of the [α/Fe] ratio.

P91

Title: Intriguing properties of ZAMS delta Scutis

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Abstract: The high precision and all-sky coverage of TESS is perfect for classical pulsators. We are carrying out a detailed study of bright delta Scuti stars over the whole sky. Our first paper (Read et al. 2024) describes a sample of 850 delta Scuti stars lying in a vertical band in the middle of the pulsation instability strip, including measurement of the pulsation fraction, the period-luminosity relation, and stars with regular spacings of peaks in amplitude spectra. Our second study investigates a population of 2000 bright stars lying close to the ZAMS, covering a wide range of colours. Using machine learning classification, we identify roughly 450 delta Scuti stars, many of which are part of binary systems or well-known open star clusters. On the blue end of the instability strip, based on their location in the CMD, spectral type and the possible presence of a binary companion, we comment on the lack of so-called "Maia" variables in our sample. Lastly, we're introducing a new automated method, dubbed collapsed echelle, to pinpoint spectra featuring harmonics. These harmonics, like those from eclipsing binaries or rotational variables, often act as contaminants when identifying delta Scuti stars.

P92

Title: New observational constraints on the mechanism responsible for the suppressed dipole-mode red giants

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Abstract: The Kepler mission provided light curves for over 16,000 red giants, of which a small fraction show reduced power in the dipole modes. We analysed both the radial and dipole modes in the power spectra of almost 600 red giants with low dipole-mode amplitudes. We found that the radial modes are unaffected by the suppression, suggesting that the suppression is mostly active in the central regions of the star. Moreover, we confirm that the majority of these stars still have observable mixed dipole modes, i.e. no complete suppression of the contribution from the inner regions to the dipole modes. This is in contradiction with the assumption of certain suppression mechanisms proposed in the literature. Finally, we also find different types of frequency-dependent suppression in the power spectra related to the stellar evolution. These new suppression types can lead to new constraints on and insights into the suppression mechanism(s) at play.

P93

Title: On the stability of toroidal magnetic fields in radiative stellar interiors

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Abstract: The stability of toroidal magnetic fields in radiative stellar interiors remains a major open issue to advance our understanding of the rotational and chemical evolution of low-mass stars. We perform 3D direct numerical simulations in a spherical geometry to examine the Tayler instability, a kink-type instability of purely toroidal fields expected to occur in stably stratified stellar interiors. The simulations are novel in that they consider a consistent background state derived from magnetohydrostatic equilibrium and explore the combined effect of gravity and thermal diffusion, as well as of fluid viscosity and magnetic resistivity. We trace the entire evolution of the instability from the linear to the nonlinear phase. Our simulations show that stable stratification and magnetic diffusivity can inhibit unstable modes, in agreement with linear stability analysis predictions by Bonanno & Urpin (2012). This suggests that toroidal fields in radiative stellar interiors may be only partially affected by Tayler instability and that the associated turbulent transport is lower than expected. These results may have implications for explaining the solid body rotation of the solar radiative core and the origin of the magnetic fields recently observed in red giant cores.

P94

Title: Single vs binary hot subdwarfs: towards the first study of a volume-limited complete sample

Author: Roberto Silvotti
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Abstract: From current statistics, based on mag-limited samples, ~35% of sdO/B hot subdwarfs are in close binaries with M-dwarf/WD companions, ~30% are in wide binaries with F/G/K MS stars, ~35% are apparently single. However, without a companion, it is hard to explain the huge mass loss near the RGB tip needed to form an sdB star. The presence of a substellar companion, difficult to detect, is a possibility. The goal of this project is to shed light on the formation mechanisms of single sdO/B stars by searching binary signatures on a small but (for the 1st time) COMPLETE 200-pc volume-limited sample using different methods/data: TESS light curves, Gaia spectra, SEDs, and precise RVs from Harps/Harps-N spectra.

P95

Title: Oscillations in Cool Dwarf stars through the spectrograph ESPRESSO

Author: Rúben António Ribeiro Costa
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Abstract: Asteroseismology has become an increasingly relevant way to determine the global properties of stars and peer into their inner structure, both through advances on the observational and theoretical side. Our work goes to its observational frontier by focusing on ε Indi, the coldest star in which asteroseismic modes have been detected, and, on the theoretical side, performs a detailed study of stellar and asteroseismic modelling. We focus on the surface term, a systematic error in oscillation frequencies between models and observations, whose cause will be closely linked to the unique properties of ε Indi, such as its large convective envelope along with a high density and opacity. To do this we created over 2000 stellar tracks until the end of the main-sequence using the stellar evolution code MESA, computing the asteroseismic modes for each model with GYRE. We then performed model optimization using AIMS, comparing our grid of models with the observations for ε Indi, utilizing the different options for the surface term correction available in it. This work enables us to know how asteroseismic properties such as the large and small frequency separation behave in K-type stars and how they depend on our grid parameters. To conclude that the different surface term corrections give compatible results in model optimization and about the impact that the different choices in the model physics can have on the mode frequencies, such as the atmosphere or convective efficiency.

P96

Title: Mapping the Distribution of accreted metals on the surface of WD G29-38 with TESS and HST

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Abstract: White dwarf (WD) star G29-38 exhibits large amplitude g-mode pulsations with frequencies ranging from 500-4000 muHz. Classified as a DAVZ (hydrogen dominated atmosphere, variable, with atmospheric metals present), it also shows an infrared excess attributed to a circumstellar dust disk. The presence of metals indicates ongoing accretion. The goal of this work is to use the pulsations to constrain the geometry of metal accretion on the surface of G29-38, e.g., polar versus equatorial. Using time series photometric data from TESS and overlapping time series spectral data from HST, we can tie its photometric variations to abundance variations derived from the time series spectra. Next, using non-linear lightcurve fitting techniques (Montgomery 2005; Montgomery et al. 2010), we can use the nonlinearities in the light curve to constrain the temperature and flux variations on its surface. The "hot spots" that occasionally appear due to pulsations will dominate the spectra, so the abundances determined from the spectra at these times will constrain the atmospheric abundances at the location of the "hot spots". We employ advanced Fourier Transform techniques to track amplitude variations in the pulsation modes. While straightforward in principle, we find that G29-38 shows such significant amplitude variations in many of its modes that a determination the pulsation amplitudes at the precise times that the HST spectra were taken is a critical part of the analysis.

P97

Title: Unveiling structures in the evolution of magnetic activity of solar-like stars

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Abstract: The magnetic and rotational properties of solar-like stars are strongly coupled due to the interaction of rotation and convection in their outer envelopes, which fuels their magnetic dynamos and as a consequence their magnetic activity cycles. Thanks to the large number of the Kepler targets with measured rotation periods and photometric magnetic activity index, Sph, we investigate how magnetic activity evolves in solar-like stars. We compute the stellar Rossby number, Ro, the ratio between the rotation period, and the convective overturn timescale, using the Yale Rotating Evolution Code. We divide our sample of main-sequence single stars by spectral type, revealing distinct patterns in their magnetic activity index relative to their Rossby number. In this talk, we will present the results of such analysis. Notably, G and K dwarfs exhibit a pronounced decline in Sph around Ro/Ro_Sun,of 0.3, indicative of a transitional phase that coincides with the location of the intermediate-rotation period gap. In contrast, F dwarfs, characterized by shallower convective zones, does not show any trend of Sph versus Ro, particularly as the effective temperature rises. These deviations likely stem from the faster evolutionary pace of F dwarfs. Our analysis indicates that the Sun shares a comparable magnetic activity level with other Sun-like stars selected with similar effective temperature and metallicity. We will discuss our findings in the context of current dynamo models.

P98

Title: Detectability of axisymmetric magnetic fields from core to the surface of oscillating post-MS stars

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Abstract: Recently, asteroseismic estimates of radial magnetic field amplitudes near the hydrogen-burning shell (H-shell) inside about 24 red-giants (RGs) have been obtained by measuring frequency splittings from their power spectra. Using general Lorentz-stress (magnetic) kernels, we investigated the potential for detectability of near-surface magnetism in a 1.3 M_sun star as it evolves from a mid sub-giant (SG) to a late SG into an RG. Based on these sensitivity kernels, we decompose an RG into three zones - deep core, H-shell, and near-surface. The SGs instead required decomposition into an inner core, an outer core, and a near-surface layer. Additionally, we find that for a low-frequency g-dominated l=1 mode in a typical stable magnetic field, ~25% of the frequency shift comes from the H-shell and the remaining from deeper layers. The ratio of the subsurface tangential field to the radial field in the H-burning shell decides if subsurface fields may be potentially detectable. For p-dominated l=1 modes close to nu_max, this ratio is around two orders of magnitude smaller in SG phases than the corresponding RG. Further, with the availability of magnetic kernels, we propose lower limits of field strengths in crucial layers of our stellar model during its evolutionary phases. The theoretical prescription we have used provides the first formal way to devise inverse problems for stellar magnetism and can be seamlessly employed for slow rotators.

P99

Title: Asteroseismology of white dwarfs with TESS

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Affiliation: CSFK, Konkoly Observatory, Budapest

Co-authors: Laszlo Molnar
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Abstract: White dwarfs (WDs) are extremely old stellar objects and are the final life stage of most of the stars. They are extremely useful astrophysical objects in the study of stellar populations and in understanding the history of our Galaxy. One of the most important properties of WDs is that they exhibit gravity-mode pulsational instabilities. We carried out a preliminary photometric analysis of a few WDs in the TESS database and thereby carried out a Fourier analysis to study their asteroseismic properties. We used the Montreal White Dwarf Database to choose our target list exhibiting spectral type DZ and Gaia magnitudes GRP brighter than 16 mag, which resulted in a total of 37 targets. DZ white dwarfs exhibit strong metal absorption lines which are useful signatures for post-main-sequence planetary systems. Of these, 33 WDs have TESS photometry and we find periodicity in 7 of them. We subsequently carried out a Fourier decomposition analysis on the periodic light curves of the 7 WDs and hereby present the Fourier parameters and amplitude spectra. To the best of our knowledge, this is the first systematic study of the variability in DZ white dwarf stars using TESS photometry. We suspect that the majority of signals are related to rotation, and compare our findings to rotation rates detected in pulsating WDs.

P100

Title: PLATO stellar rotation and activity measurements

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Abstract: The PLATO stellar analysis pipeline will provide photometric rotation and activity measurements for as many observed stars as possible. This poster is aimed at presenting the scientific abilities of the rotation and activity analysis module that will be implemented in the PLATO pipeline. The strategy combines Fourier analysis, autocorrelation of time series and machine learning classifiers to extract both stellar surface rotation and long-term modulations related to stellar magnetic activity that might be detectable in the light curve. The ROOSTER random forest methodology guarantees the completeness and the robustness of this automated analysis. To showcase the potential of the designed framework, the algorithms were applied on a set of simulated light curves including spot evolution and migration, magnetic activity cycle, convective granulation, PLATO systematics, and random camera noise. From that analysis, we demonstrate that PLATO should already be able to provide rotation periods and photometric activity indexes for a large sample after six first months of observation, and that the quality of these measurements will be refined as longer time series are acquired.

P101

Title: Modelling photospheric active regions in Kepler solar-type pulsators

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Abstract: In the absence of resolved observations of a star, starspot modelling provides the opportunity to reconstruct maps of brightness inhomogeneities in the stellar photosphere. This approach is particularly important in the context of the PLATO mission, where interferometric observations will be available only for a small subset of the observed stars. Therefore, in order to explore the possibility to reconstruct reliable starspot distributions of moderately active solar-type stars that will be at the core of PLATO science, we implemented a Bayesian continuous grid model accounting for spots and faculae contribution. We demonstrate the robustness of our method by comparing the reconstructed solar spot longitudinal distribution with the actual observed distribution during Cycles 23 and 24. Applying the method on ten Kepler asteroseismic targets, we find signatures of stable active nests for seven of them and we investigate cyclic modulations that might be related to magneto-inertial waves propagating in the envelope, opening the perspective to probe the magnetic field amplitude in the tachocline.

P102

Title: Towards ensemble asteroseismology of pulsating hot subluminous stars

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Abstract: Hot subluminous stars are hot and compact core-helium burning objects with a thin hydrogen envelope, located on the horizontal branch between the main sequence and the white dwarf sequence, occupying the B and O (sdB and sdO) spectral types. As a sub-group of these stars has been observed to exhibit multi-periodic, low-amplitude light variations caused by non-radial pulsations, they offer a unique opportunity to probe the interior of hot subluminous stars using asteroseismology. However, the number of known pulsating subdwarfs is small, limiting their asteroseismic potential. This work primarily focuses on identifying and modelling pulsating hot subdwarfs by leveraging both space and ground-based multi-colour time series observations, such as TESS, Gaia, and BlackGEM. Our preliminary results reveal several new objects, observed from TESS and Gaia, with pulsation frequencies in the g-mode regime. We further model the observed amplitude ratios of these stars, by comparing observed pulsation amplitudes with theoretical predictions in order to identify the pulsation mode geometries and make inferences on the astrophysical parameters of these stars. By generalising this method, we make the first steps towards constructing observational instability strips for different mode geometries for subdwarfs.

P103

Title: A catalogue of asteroseismically calibrated ages for APOGEE DR17.

Author: Thibault Boulet
Affiliation: IA-CAUP

Abstract: Understanding the Milky Way's formation and evolution requires precise stellar age determination across its components. Recent advances in asteroseismology, spectroscopy, stellar modeling, and machine learning, along with all-sky surveys, have provided reliable stellar age estimates. We aim to furnish accurate age assessments for the Main Red Star Sample within the APOGEE DR17 catalogue. Leveraging asteroseismic age constraints, we employ machine learning to achieve this goal. We explore optimal non-asteroseismic stellar parameters, including Teff, L, [CI/N], [Mg/Ce], [α/Fe], U(LSR) velocity, and 'Z' vertical height from the Galactic plane, to predict ages via categorical gradient boost decision trees. Our model, trained on merged samples from TESS and APOKASC catalogs, achieves a median fractional age error of 20.8%, with a variance of 4.77%. For stars older than 3 Gyr, the error ranges from 7% to 23%, for those between 1 and 3 Gyr, it is 26% to 28%, and for stars younger than 1 Gyr, it is 43%. Applied to 125,445 stars, our analysis confirms the flaring of the young Galactic disc and reveals an age gradient among the youngest Galactic plane stars. We also identify two groups of metal-poor ([Fe/H] < -1 dex) and young (Age < 2 Gyr) stars exhibiting similar chemical abundances and halo kinematics, likely remnants of the predicted third gas infall episode around 2.7 Gyr ago.

P104

Title: Gamma Doradus Stars: Realistic frequency yields from TESS Photometry and HERCULES Spectroscopy

Author: Thomas Shutt
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Co-authors: Emily Brunsden
Co-authors affiliation: University of York

Abstract: This work explores the potential of combined TESS photometry and HERCULES spectroscopy in the asteroseismic investigation of Gamma Doradus stars. We examine the efficacy of existing pipelines and software with the aim of providing frequency outputs with meaningful uncertainties. We discuss the reliability of derived datasets and the achievable frequency yield with the aim of enhancing our ability to derive Gamma Doradus stars' physical parameters.

P105

Title: A search for long-term variations in asteroseismic parameters of Kepler red giants

Author: Tim Bedding
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Abstract: Despite decades of observations of the solar cycle, the underlying mechanism is not entirely understood. Observation of activity cycles in stars that evolved further from the main sequence, such as red giants, may help put additional constraints in the dynamo models. The surface magnetic fields sustained by the dynamo are known to affect the oscillations inside the stars. Observations of the Sun have shown that the oscillation frequencies change in phase while the mode amplitudes change out of phase with the solar cycle. Similar observations have been made on other solar-type stars using asteroseismology to detect activity cycles. Using the long-cadence photometric data from Kepler, we analysed the long-term trends in the global asteroseismic parameters of 16,094 red giants with solar-like oscillations. We identified stars displaying significant variation in these parameters by studying the long-term trends and computed their mean frequency for each Kepler quarter using a cross-correlation method. We estimated the error bars of these shifts using Monte Carlo simulations. The expected frequency shifts for red giants were predicted to be a few muHz, but our results show the shifts to be around 1/100-1/10th of a muHz. Additionally, we found that the estimated error bars are significantly larger than the quarterly variations in frequency shifts, making it challenging to detect activity cycles in red giants.

P106

Title: Asteroseismology of Long Period Variables Using Kepler and TESS

Author: Tim Bedding
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Co-authors: Filip Chatys (1); Timothy R. Bedding (1); Daniel Huber (1,2); Yaguang Li (2); Jie Yu (3)
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Abstract: We study pulsation characteristics and period-luminosity (P-L) relations of LPVs, including Miras and semi-regular variables (SRs} using data from the Kepler and TESS missions. By combining high-precision photometric observations from Kepler and TESS with spectroscopic and asteroseismic properties from the APOKASC-2 catalogue, as well as Gaia DR2 and DR3 parallaxes, we aim to validate and refine seismic scaling relations for red giants. We compare luminosities and radii derived from asteroseismology with those obtained using Gaia data, highlighting the precision of Gaia DR3 parallaxes. We also analyse high-luminosity red giants using TESS data, to test the seismic scaling relations and investigate the interactions between pulsations and radiation in driving mass loss events. Our aim is to enhance our understanding of the pulsation mechanisms and mass loss processes in LPVs, contributing to improved models of stellar and Galactic evolution. The results underscore the potential of LPVs, especially Miras, as distance indicators due to their well-defined period-luminosity relation. Furthermore, by using the TESS data we aim to refine our knowledge of the stellar evolution and the chemical enrichment of galaxies.

P107

Title: Beyond forward modelling: non-linear structure inversions for g-mode pulsators

Author: Vincent Vanlaer
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Abstract: Stellar evolution presents a complicated challenge, with gaps in our knowledge affecting many aspects of astronomy, such as exoplanet characterization and galactic chemical evolution. Luckily, space telescopes like Kepler and TESS give us light curves for millions of objects. By studying the pulsating stars among these, we are able to use the precision of this data to probe the internal structure and evolution of stars in great detail, across all masses and evolutionary stages. However, just having access to these large datasets and their observational diagnostics is not sufficient: the modelling techniques and the stellar models themselves need to be sufficiently advanced and efficient to exploit the data maximally. One of the more advanced modelling techniques are structure inversions, which attempt to more directly reconstruct the internal structure of the star from the pulsation frequencies. However, for intermediate- and high-mass stars with g-mode pulsations, typical inversions techniques are not feasible, as avoided crossings break the assumptions of linearity. Hence, we developed a new non-linear inversion technique that is suitable for g-mode inversions. In this talk I will explain the ideas behind this non-linear inversion technique, and compare with other non-linear inversion methods that have been recently developed. I will also discuss some of our first results with these new inversion methods.

P108

Title: Mixed mode coupling in the Red Clump: Standard single star models

Author: Walter van Rossem
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Abstract: The investigation of global, resonant oscillation modes in red giant stars offers valuable insights into their internal structures. In this study, we investigate the information we can recover on the structural properties of core-helium burning stars by examining how the coupling between gravity- and pressure-mode cavities depends on several stellar properties, including mass, chemical composition, evolutionary state, and core-to-envelope mass ratio. Using the structure of models computed with the stellar evolution code MESA we compute the coupling coefficient implementing analytical expressions appropriate for the strong coupling regime, which well describes the structure of the evanescent region in core-helium burning stars. Our analysis reveals a notable anti-correlation between the coupling coefficient and both the mass and metallicity of stars in the regime $M \lesssim 1.8~\msol$, in agreement with Kepler data, attributing this primarily to variations in the density contrast between the stellar envelope and core. The strongest coupling is expected thus for red-horizontal branch stars, partially stripped stars, and stars in the higher-mass range exhibiting solar-like oscillations ($M \gtrsim 1.8~\msol$). While our investigation emphasises some limitations of current analytical expressions, it also presents promising avenues. The frequency dependence of the coupling coefficient emerges as a potential tool for reconstructing the stratification of the evanescent region.

P109

Title: Realistic Uncertainties for Fundamental Properties of Asteroseismic Red Giants

Author: Yaguang Li
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Co-authors: Tim Bedding (1); Daniel Huber (1); Dennis Stello (2); Jennifer van Saders (3); Yixiao Zhou (4); Courtney Crawford (1); Meridith Joyce (5); Tanda Li (6); Simon J. Murphy (7); K. R. Sreenivas (1)
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Abstract: Asteroseismic modelling is a powerful way to derive stellar properties. However, the derived quantities are limited by built-in assumptions used in stellar models. This work presents a detailed characterisation of stellar model uncertainties in asteroseismic red giants, focusing on the mixing-length parameter (amlt), the initial helium fraction (Yinit), etc. First, we estimate error floors due to model uncertainties to be ~0.4 in mass, ~0.2% in radius, and ~17% in age, due to the uncertain state of amlt and Yinit. The systematic errors in age exceed typical statistical errors. Second, we demonstrate that the uncertainties from amlt can be entirely mitigated by direct radius measurements or partially through numax. Utilizing radii from eclipsing binaries, we determined the amlt values and calibrated the amlt-[M/H] relation. The correlation observed between the two variables is consistent with previous studies using 1-D stellar models, but in contrast with 3-D simulations. Third, we explore the implications of using asteroseismic modelling to test the numax scaling relation. We found that a perceived dependency of numax on [M/H] from frequency modelling can be largely removed by incorporating the calibrated amlt--[M/H] relation. These findings suggest that numax conveys information not fully captured by individual frequencies, and that it should be carefully considered as an important observable for asteroseismic modelling.

P110

Title: Dating Cool Main-Sequence Stars with the Activity-Age Relation

Author: Yaguang Li
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Co-authors: Tanda Li (1); Jennifer van Saders (2); Daniel Huber (2); Jinghua Zhang (3); Jie Yu (4); Shaolan Bi (1); Travis Metcalfe (5)
Co-authors affiliation: (1) Beijing Normal University; (2) University of Hawai`i; (3) Yunnan University; (4) Australian National University; (5) White Dwarf Research Corporation

Abstract: Investigating the relationship between age and activity in cool stars was faced with two main challenges. The first challenge is the measurement of activity indices across a wide range of stellar parameters, which demands extended periods of observation for numerous stars. All-sky surveys such as LAMOST facilitate addressing this challenge by providing activity indices for millions of stars. The second challenge is the accurate estimation of stellar ages, especially for K-type stars. Recent studies have shown that kinematic velocity dispersion can serve as a reliable indicator of age for stars in the solar neighborhood. In this work, we have mapped the relationship between kinematic ages and LAMOST measured activity indices (log R'HK), for stars between 6,000 K and 4,000 K. We found that K-type stars exhibit a relationship that is similar to those found in G- and F-type stars, but with a generally higher activity level. Using the ages derived from activity levels, we have observed a disruption in the spin-down process in older main-sequence stars, adding another piece of evidence to the theory of weakened magnetic braking.

P111

Title: Asteroseismic Frequency Spacings of Kepler Red Giants Using Collapsed ´Echelle Diagrams

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Abstract: The goal of this work is to develop a method which can automatically measuring $\Delta\nu$, ε and $\delta\nu_{02}$ for oscillating red giants. The process calculates and segments the power spectrum to create the collapsed \'echelle diagram, which aids in estimating frequency separations and other oscillation parameters. We re-measured the mean large frequency separation for 16,000 Kepler red giants, with typical uncertainty $\sigma_{\Delta\nu}$ = 1.0\%$. This method operates independently from the SYD pipeline, revealing its shortcomings in estimating the $\Delta\nu$ for red giants with ν_{max} exceeding 120μHz.

P112

Title: The Roman Road to Stellar Rotation: Rotation and Spots with Roman's Time Domain Surveys

Author: Zach Claytor
Affiliation: Space Telescope Science Institute

Co-authors: Jamie Tayar (1)
Co-authors affiliation: University of Florida

Abstract: We have used machine learning to study stellar rotation in TESS despite the mission's complicated systematics. The upcoming Nancy Grace Roman Space Telescope will perform time domain surveys at multiple wavelengths that stand to increase the number of period measurements and offer temperature resolution for star spot properties, shedding light on the connections between rotation and magnetism. However, the survey design is not yet decided, and certain choices may be critical to ensure sufficient cadence, baseline, and wavelength coverage for stellar rotation science. We are using the simulation and machine learning framework developed for TESS to predict the optimal Roman survey design for stellar rotation. I will discuss our framework and illustrate how existing machine learning tools can inform decisions for survey design. I will consider the stellar populations and periods Roman will be sensitive to and preview the transformational science Roman will enable.

P113

Title: Asymmetric rotational splittings of Delta Scuti p modes reveal the non-spherical distortion

Author: Zhao Guo
Affiliation: KU Leuven

Co-authors: T. Bedding, A. Pamyatnykh, Don Kurtz, Gang Li
Co-authors affiliation: University of Sydney; Copernicus Astronomical Center, Warsaw;, North-West University, South Africa; KU Leuven

Abstract: We find that the observed pressure-mode rotational splittings of slowly rotating Delta Scuti stars almost all have positive asymmetry. That is, the left frequency spacing is larger than the right spacing in the dipole-mode splitting triplets and the l=2 mode splitting quintuplets/quadruplets. This is in agreement with the 2nd-order perturbative effect on the acoustic modes from the rotational non-spherical distortion. We thus systematically study the rotational perturbation both in the 1st order and 2nd-order, as well as the near-degeneracy mode coupling effect to grids of MESA models for Delta Scuti stars. For faster rotators, we include another 2nd-order effect, the near-degeneracy mode coupling between nearest radial and quadruple modes, which can significantly shift the $m=0$ modes and change the large-frequency separation Delta \nu by 0.1 per day, and the curvature of the radial ridges. It can also make the asymmetry parameter smaller and even change its sign. We discuss other factors that can reduce the rotational asymmetry such as embedded magnetic fields, and nonlinear mode coupling.

P114

Title: TESS observations of the ZZ Ceti star WD 1310+583

Author: Zsófia Bognár
Affiliation: Konkoly Observatory, HUN-REN CSFK

Abstract: WD 1310+583 is a bright (G=14.1 mag) ZZ Ceti star; its light variations were discovered just before the launch of the TESS space telescope. TESS collected data both in 120-sec short-cadence mode (7 sectors), and in 20-sec ultrashort-cadence mode (4 sectors) on this white dwarf. The light-curve analysis of the observations from different sectors revealed numerous candidate pulsation modes for the star, and we can find several closely spaced frequencies ("forest of peaks") above about 700 sec, as it is expected in this period region. For producing our period list, we calculated the amplitude-weighted periods of the peaks detected at similar frequencies in different sectors. The final list of observed periods consist of more than a dozen independent modes. Therefore, WD 1310+583 is a ZZ Ceti star rich in pulsation modes, which means strong constraints for the future asteroseismic modeling of the star.

Online-only Posters[4]

[4] Abstract, author, and affiliation information is displayed as provided by the authors (i.e., unedited).

OP1

Title: Comparative analysis of mass determination methods for pulsating white dwarfs

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Abstract: A central challenge in the field of stellar astrophysics lies in accurately determining the mass of stars. For isolated pulsating white dwarf (WD) stars, we can assess the stellar mass by means of different approaches such as spectroscopy, asteroseismology, and astrometry. The objective of this work is to compare in detail the stellar mass values derived through these methods. Our analysis encompasses a selection of DAV stars (pulsating H-rich WDs), DBV stars (pulsating He-rich WDs), and GW Vir stars (very hot pulsating WDs with atmospheres rich in C, O, and He). We calculated spectroscopic masses, compiled seismological masses, and, for the first time, determined astrometric masses. We compared the three sets of stellar masses obtained through these different methods. To ensure consistency and robustness in our comparisons, we utilized identical WD models and evolutionary tracks across all three methods. Our analysis suggests a general consensus among the three methods regarding the masses of DAV stars, especially for objects with masses below approximately 0.75 Msun, although notable disparities emerge for certain massive stars. For DBV stars, we find that astrometric masses generally exceed seismological and spectroscopic masses. Finally, while there is agreement among the sets of stellar masses for some GW Vir stars, outliers exist where mass determinations by various methods show significant discrepancies.

OP2

Title: On deciphering stellar surface magnetic fields using precision limb darkening measurements

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Abstract: The high-precision measurements of exoplanet transit light curves contain information about the planet properties, their orbital parameters, and stellar limb darkening (LD). Recent 3D magneto-hydrodynamical (MHD) simulations of stellar atmospheres have shown that LD depends on the photospheric magnetic field, and hence its precise determination can be used to estimate the field strength. Among existing LD laws, the uses of the simplest ones may lead to biased inferences, whereas the uses of complex laws typically lead to a large degeneracy among the LD parameters. We have developed a novel approach in which we use a complex LD model but with second derivative regularisation. Regularisation controls the complexity of the model appropriately and reduces the degeneracy among LD parameters, thus resulting in precise inferences. The tests on simulated data suggest that our inferences are not only precise but also accurate. This technique is used to re-analyse 43 transit light curves measured by the NASA Kepler and TESS missions. Comparisons of our LD inferences with the corresponding literature values show good agreement, while the precisions of our measurements are better by up to a factor of 2. We find that 1D non-magnetic model atmospheres fail to reproduce the observations while 3D MHD simulations are qualitatively consistent. The LD measurements together with MHD simulations confirm that Kepler-17, WASP-18, and KELT-24 have relatively high magnetic fields (> 200 G).

OP3

Title: Empirical instability strip for classical Cepheids in the Magellanic Clouds

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Abstract: The instability strip (IS) of classical Cepheids has been extensively studied theoretically. Using the most recent Cepheids catalogs, we can compare the empirical IS edges with those obtained theoretically to gain insights into the physical processes that determine the position of the IS boundaries. We investigate the empirical positions of the IS of the classical Cepheids in the Magellanic Clouds while considering various effects that increase its width to obtain intrinsic edges that can be compared with theoretical models. We used data for classical fundamental-mode (F) and first-overtone (1O) Cepheids from the OGLE-IV variable star catalog and a recent high-resolution reddening map from the literature. We then studied their position in the Hertzsprung-Russell diagram and determined the IS borders by tracing the edges of the color distribution along the strip. We obtained the blue and red edges of the IS in V and I photometric bands, in addition to log T_eff and log L. The results obtained show features in the IS located at the Cepheids period of about two and three days. We compared our empirical borders with theoretical ones published in the literature, obtaining a good agreement for specific parameter sets. The features observed in the IS borders are most likely related to the interplay between metallicity effects, and the depopulation of second- and third-crossing classical Cepheids in the faint part of the IS. Results from the comparison of our empirical borders wit

OP4

Title: Is the orbit of WASP-19b decaying?

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Abstract: Transit timing variations (TTVs) have proven to be a very valuable tool in the field of exoplanetary detection. Currently, WASP-4 and WASP-12 stand out as the most promising candidates exhibiting TTVs. We have presented here the transit timing variation analysis of the exoplanet WASP-19b, one of the first detected ultrashort period gas giant planets. For this, we have considered total 250 complete transits, which include 116 light curves from Transiting Exoplanet Survey Satellite, a space based telescope, 62 complete transit light curves from Exoplanet Transit Database and 72 from the literature, covering a 13-yr baseline. We found a TTV of amplitude 66.83s and we further investigated the possible origin of the observed TTV. To assess the short-term TTV, we computed the false alarm probability (FAP) corresponding to the highest power peak using the generalized Lomb-Scargle periodogram. The calculated FAP value is 15%, which falls below the threshold values of 5% and 1%. Due to lack of periodicity, we excluded short-term TTV and looked for long-term TTV. The orbital decay appears to be the most plausible cause for the observed TTV and in order to confirm these findings, further high-precision transit observations of the system would be worthwhile.

OP5

Title: Tidal torque balance in stars and gaseous planets

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Abstract: Tidal torques can alter the spins of tidally interacting stars and planets, usually over shorter timescales than the tidal damping of orbital separations or eccentricities. Simple tidal models predict that in eccentric binary or planetary systems, rotation periods will rapidly evolve toward a “pseudosynchronous” ratio with the orbital period. However, this simple prediction does not account for “inertial” waves that are intrinsic to stars and gaseous planets with (i) convective regions, and (ii) even very slow rotation (inertial oscillations have recently been detected in our own Sun). I will describe new results demonstrating that tidal driving of inertial oscillations in eccentric systems can counterbalance the equilibrium tidal torque at numerous ratios of orbital to rotation period that can deviate significantly from the pseudosynchronous prediction. By introducing a network of easily predictable period ratios at which the total tidal torque vanishes, inertial oscillations may impede the process spin pseudosynchronization in low-mass stars and gaseous planets with convective envelopes.

OP6

Title: Detection of Solar-like Oscillations in Subgiant and Red Giant Stars Using 2-Min Cadence TESS Data

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Abstract: Based on all 2 minute cadence TESS light curves from Sector 1 to 60, we provide a catalog of 8651 solar-like oscillators, including frequency at maximum power (nu_max, with its median precision sigma = 5.39%), large frequency separation (delta_nu, sigma = 6.22%), and seismically derived masses, radii, and surface gravity values. In this sample, we have detected 2173 new oscillators and added 4373 new Delta_nu measurements. Our seismic parameters are consistent with those from Kepler, K2, and previous TESS data. The median fractional residual in nu_max is 1.63%, with a scatter of 14.75%, and in delta_nu it is 0.11%, with a scatter of 10.76%. We have detected 476 solar-like oscillators with nu_max exceeding the Nyquist frequency of Kepler long-cadence data during the evolutionary phases of subgiants and the base of the red giant branch, which provide a valuable resource for understanding angular momentum transport.

OP7

Title: Carbon deficiency in red clump stars: asteroseismology sheds light on merger origin

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Abstract: Weak G-band stars, or carbon-deficient red giants (CDGs), are a rare class of chemically peculiar G and K giants with carbon abundances that are under-abundant by about a factor of 20 when compared to that of the normal giants. Despite their discovery nearly 70 years ago, the origin of carbon deficiency remains a puzzle. We aimed to better characterize the CDGs by using asteroseismology (Kepler, TESS), spectroscopy (APOGEE, LAMOST), and astrometry (Gaia). We identified 15 new CDGs in the Kepler field and for the first time, unambiguously identified their evolutionary state as being in the red clump phase. Our findings reveal that CDGs are primarily low-mass stars ($M \lesssim 2$ Msun), unlike previous suggestions of intermediate-mass (2.5–5.0 Msun) based on the HRD. The demarcations in chemical patterns and luminosities led us to categorize them into three groups. We concluded that a merger of a helium white dwarf with a red giant branch star is the most likely scenario for the two groups of over-luminous stars. For the normal-luminosity CDGs, we could not distinguish between core He-flash pollution or lower-mass merger scenarios. The strong correlation between CDGs and Li-rich giants suggests a potential link between their formation processes.

OP8

Title: Precision and Accuracy of Detailed Modelling inferences for Kepler and K2 Red Giants

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Abstract: Asteroseismology probes the internal structure and can hence well characterize stars. This poster demonstrates that detailed asteroseismic modeling can infer masses, ages, and radii for red-giant stars with high precision and good accuracy. We extract individual mode frequencies and use them to characterize more than 3,000 Kepler red-giant stars. The typical precision for the best star sample is 3% for mass, 11% for age, and 1% for radius. The accuracy of our modeling inference is validated with 5 red giants in the eclipsing binary systems and 3 early red giants in the open cluster M67. Good consistency is found between seismic determinations and masses, ages, and radii estimates with other methods.

OP9

Title: Asteroseismic analysis of the bright sdB pulsator TIC 441725813 from TESS time series photometry

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Abstract: Contemporary high-precision photometry from space provided by the TESS satellites generates significant throughs in terms of exploiting the pulsating hot B subdwarf (sdBV) stars with asteroseismology. We present a detailed asteroseismic study of the sdBVs star TIC 441725813 monitored with TESS. We analyse the spectroscopy of TIC 441725813 using appropriate NLTE model atmospheres to provide accurate atmospheric parameters for this star. We also reanalyse the TESS light curve using standard prewhitening techniques. On this basis, we apply a forward modeling technique using our latest generation of sdB seismic models. The light curve analysis reveals 44 frequencies that can be associated with oscillation modes of different degree l and/or radial order k. All the modulations observed in this star correspond to g-mode pulsations except 4 high-frequency signals, which are typical of p-mode oscillations. The seismic analysis leads us to identify a preliminary model solution that can account for the observed pulsation properties of TIC 441725813. Despite remaining ambiguities, several key structural parameters of the star are derived with stringent constraints, such as its mass, radius, H-rich envelope mass, and luminosity.